POWER PLANT ENGINEERING

Established Over 29 Years

VOL. XXIX CHICAGO, OCTOBER 1, 1925 No. 19

Contents of this Issue

Page

Lansing Improves District Heating Service. By J. E. Woodwell. Illustrated 984
Burning Natural Gas & Oil. Illustrated....989
Simplifying the Boiler Heat Balance. By J. R. Darnell.....990
Unit Systems of Pulverizing and Burning Coal. By W. C. Heckeroth. Illustrated 993
Thrust Bearing on Turbine Changed. By R. H. Morris. Illustrated 995
Useful Uniflow Engine Calculations. By Fred William Bosch. Illustrated 997
Oil Engines in the Pumping Field. By F. Johnstone-Taylor. Illustrated 999
The Deadly "Short-Cut"....1001
Relay Protection of Transmission Lines. By C. A. Anderson. Illustrated 1002
Electrical Apparatus Shows Steady Progress. Illustrated...1004
Evolution of the Synchronous Motor. By Theo Schou. Illustrated 1008
Simple Tests Show Quality of Leather Belting. By Louis W. Arny. Illustrated....1010
Revamping Plant Cuts Coal Bill 100 Per Cent. Illustrated..1012
Spray Cooling Systems for Ammonia Condensers. By C. R. Kranz. Illustrated 1015
Letters Direct from the Plant: Dry Wood Waste Affects Brick Work Maintenance. Making Old Engines Show Profit. Separator Trap Easily Made. Leak in Boiler Joint Located by Compressed Air. Illustrated.....1016
Questions and Answers: Why Is Super-heated Steam Used? Cards Show Need of Increased Pressure. Restricted Steam Supply Cause of Pressure Drop. Indicator Compression Lines Show Leaks. What Size Economizer Is Needed? When D.C. Produces A.C. Illustrated....1019
Editorial Comment: To Whom Is the Engineer Responsible? Executives Must Not Always Avoid Details. Wanted, a Hydrogen-Tight Shaft Packing. Fairness Requisite for Continued Success. New Power Plants Aid Community Development 1022
N. A. S. E. Holds 43rd Convention at St. Paul. Illustrated.1024
Largest Jet Condenser Undergoes Test. Illustrated.....1028
Recording Coal and Ash Weights While Conveying. Illustrated 1028
Continuous Slicing Breaks Up Clinkers. Illustrated.....1029
Conveyor Chains of Special Material....1029
F. C. Houghton, New Director of A. S. H. V. E. Research Laboratory 1030
Large Hydro Plant Planned for Louisville....1030
Beaumont, Texas, to Have 300,000 Kw. Plant....1030
Progress Being Made in Deerfield Development....1030
News Notes 1031
Catalog Notes 1032

Published on the 1st and 15th of each Month by the

Technical Publishing Co., 537 So. Dearborn Street, Chicago

New York Office, 150 Nassau Street

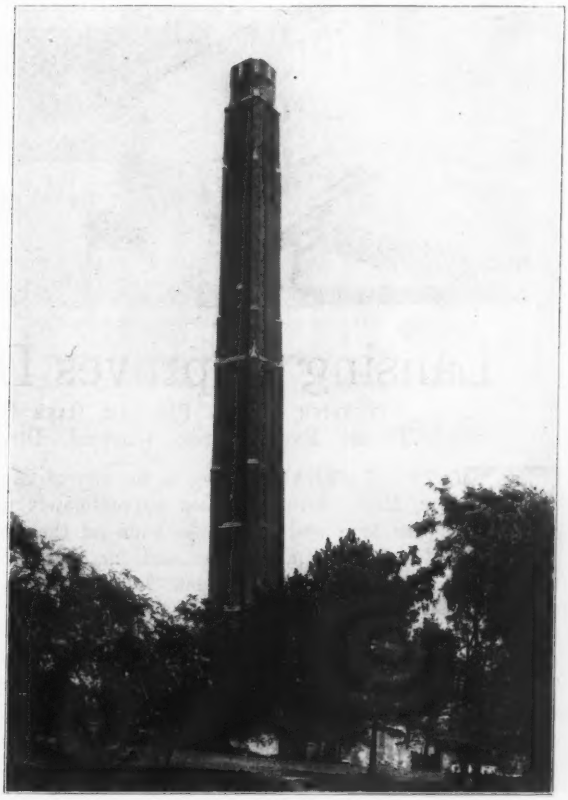
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year.

Single copies 15 cents. Copyright 1925, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue, 23,350



CHIMNEYS to give draft must reach far upward, like church spires or memorial towers. In house architecture the chimney is used as an effective part of the ornamentation without detracting from its usefulness. In churches, and public buildings, towers and spires are used for their beauty alone. Why should not the power plant chimney be a delight to the beholder as well as serving its prime purpose?

In the illustration is shown one positive answer. This chimney, built for Washington University at St. Louis, was planned by Jamieson & Spearl, architects, to harmonize with the buildings, to add to the attractiveness of the campus and to give the needed draft for the boilers. It is 175 ft. high, 8 ft. diam., the core of hollow building tile filled with reinforcing rings and bars and concrete, on the Wiederholdt system. The exterior is of cut stone and different colored brick, combined so as to match the granite color of the University buildings.

Look again at its simplicity and grandeur; comparable to the best of the world's cathedral towers. Some extra cost, yes. But a chimney is unavoidably a conspicuous object. Isn't it worth while, for a few per cent added cost, to make it conspicuous for its beauty?

Lansing Improves District Heating Service

EXTENSIVE PAVING PROGRAM GAVE OPPORTUNITY TO MAKE DISTRIBUTION SYSTEM LARGE ENOUGH FOR GROWTH DURING 10-YR. PERIOD. BY J. E. WOODWELL*

DISTRICT STEAM heating in the city of Lansing, Mich., covers an area approximately ten blocks long and six blocks wide on the west side of the Grand River and for six blocks fronting on East Michigan Ave. on the east side of the Grand River. Steam for the system on the west side is supplied from the combined steam and electric generating station at the foot of East Ottawa St. This plant was originally constructed and owned by the Michigan Light and Power Co., having been sold to the city in 1920. The original company had developed and expanded the steam heat business in 1897. Steam for the system on the east side of the river is furnished by the municipal water works pumping station on Cedar St.

Total amount of radiation now connected to the system is over 375,000 sq. ft., the classification of the buildings supplied with steam being shown in Fig. 1. The sizes and approximate location of the mains and branch mains are shown on the accompanying map, Fig. 2.

For several years prior to the date of purchase of the steam heat system by the city, comparatively little effort was made to expand the business and it was not until 1921 and 1922, when the overloading of the mains made some reconstruction necessary, that the engineering and economic phases of the steam heat business were carefully investigated.

During the year 1922 temporary relief was obtained by running a 4-in. high pressure booster line from the Ottawa St. Station to Manhole No. 98 at the intersection of Washtenaw St. and Washington Ave., a distance of 2100 ft., and in the fall of 1923 this 4-in. booster line was extended from Manhole No. 98 by a new 6-in. high-pressure line run to the Porter apartments, on the southeast corner of Townsend and Lenawee Sts., a distance of 2000 ft., serving also a group of houses in the same block. The purpose of this booster line was not only to provide for the large concentrated steam demand of the Downey Hotel and the Porter apartments, but to boost the pressure in the low-pressure exhaust steam system at points along the line, thus increasing the capacity and extending the area served in the south side of the city.

Small extensions to the low-pressure system, principally in the residence districts, were also made during the years 1922 and 1923 in different parts of the city as a result of insistent demands for service by property owners and other citizens. In 1923 and 1924 an extensive program for repaving the principal streets in the steam heating area of the city was made and at that time it was considered advisable to study the entire system of distribution with a view to enlarging the trunk and branch mains to provide for an anticipated growth during a 10-yr. period.

Increasing difficulties of securing at a reasonable price, a fuel for domestic heating purposes, uncertainty of deliveries, inconveniences and cost of labor for attendance to house heating boilers, removal of ash and the nuisance of dust and smoke, have combined to set forth strongly in the mind of the public the advantages of central station heating, where at a reasonable cost and with the convenience comparable to an electric switch, heat may be turned either on or off.

This service is rendered possible by reason of the superior economies of operation obtainable in a modern central station boiler plant wherein fuel bought at the lowest wholesale prices may be stored, handled and burned efficiently. Furthermore, it is possible to pass a large part of the steam distributed throughout the city, through a steam turbine of special design and generate electric current as a by-product with only a small reduction in the heating value of the steam generated in the boiler plant.

As against these well recognized advantages and economies of the central station system of heating, we have

* Consulting Engineer.

the charges of investment and maintenance of an expensive system of heat-insulated, underground mains and laterals, with manholes, meters and traps. The heat loss between the station and the customer is determined by the degree of perfection of the heat insulation and type of underground construction. This loss in a properly designed system should be between the limits of 5 and 15 per cent of the annual demand, the actual percentage being influenced primarily by the relation of steam heat loads to the area covered.

It is evident, therefore, that the commercial success of central station heating depends almost entirely upon the distributing system, its cost, maintenance and efficiency. It is unlike the supply of electric energy, where the losses accompanying distribution vary with the demand. The supply of steam through mains is accompanied by practically the same loss of heat, irrespective of the demand or flow through the pipes. Obviously as the losses of heat in a given piping system are practically constant, the more nearly the system is loaded to capacity the lower will be the percentage of heat loss as compared to the total amount of steam delivered and sold.

Small customers at the end of long lines or users located in areas distant from the station will be difficult to serve economically and it is therefore necessary to limit the boundaries of the area to be served so that the costs and losses of the piping system within that area will not exceed a figure which would prevent a fair return on the investment and at the same time the rates for steam heat should be sufficiently attractive so that business can be secured.

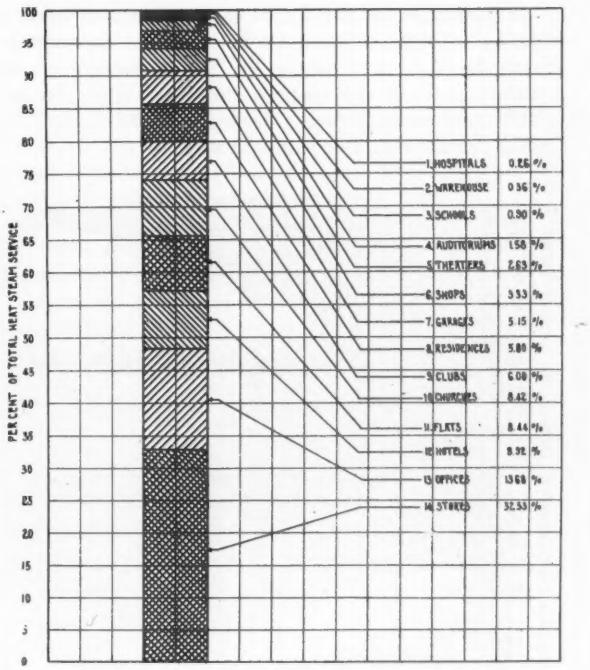

PER CENT OF TOTAL HEAT STEAM SERVICE
1. HOSPITALS 0.26 %
2. WAREHOUSE 0.36 %
3. SCHOOLS 0.90 %
4. AUDITORIUMS 1.58 %
5. THEATERS 2.63 %
6. SHOPS 3.33 %
7. GARAGES 5.15 %
8. RESIDENCES 5.80 %
9. CLUBS 6.08 %
10. CHURCHES 8.42 %
11. FLATS 8.44 %
12. HOTELS 8.92 %
13. OFFICES 13.68 %
14. STORES 32.53 %

FIG. 1. CLASSIFICATION OF THE BUILDINGS SUPPLIED WITH STEAM

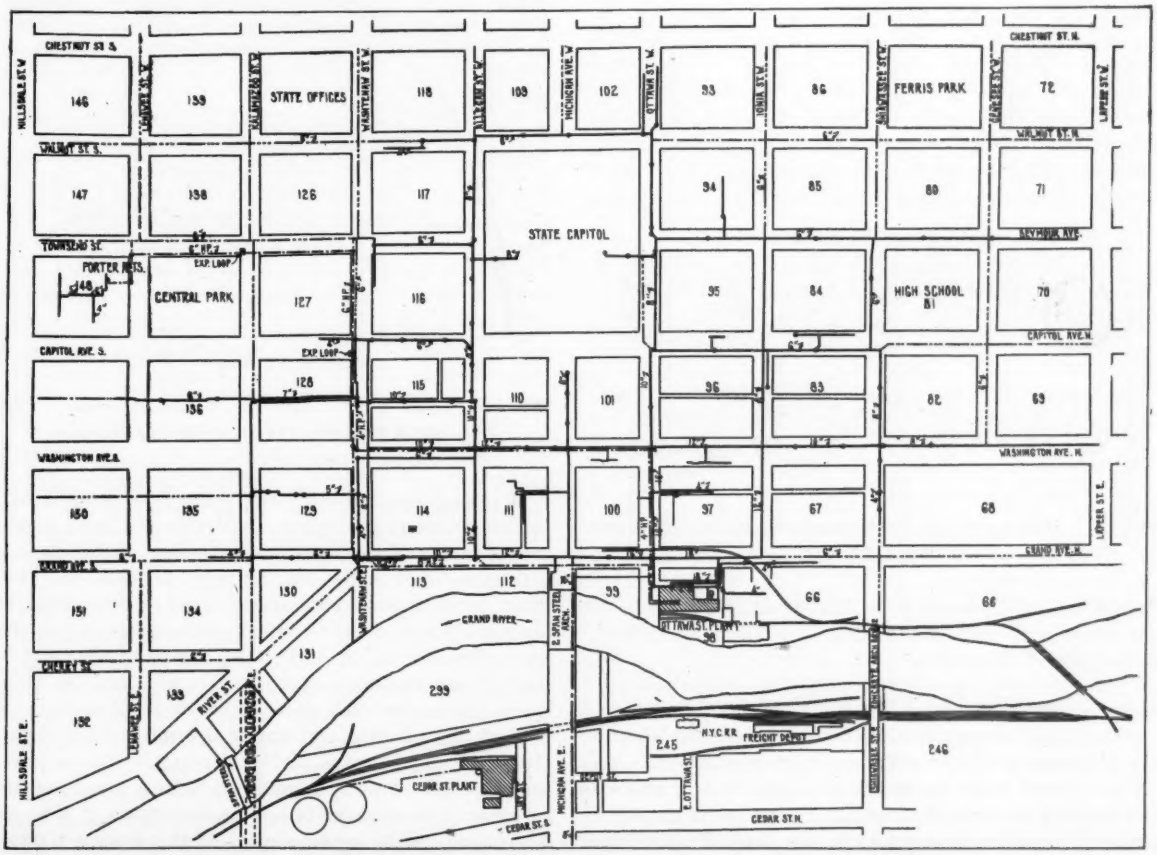


FIG. 2. GENERAL LAYOUT SHOWING THE DISTRIBUTION MAINS AT LANSING

In planning for the future, however, mains must be installed of sufficient size to take care of an expected growth for 5 yr. at least, as the cost of tearing up and resurfacing streets at frequent intervals would be prohibitive and alterations can be made to advantage only during the three or four summer months.

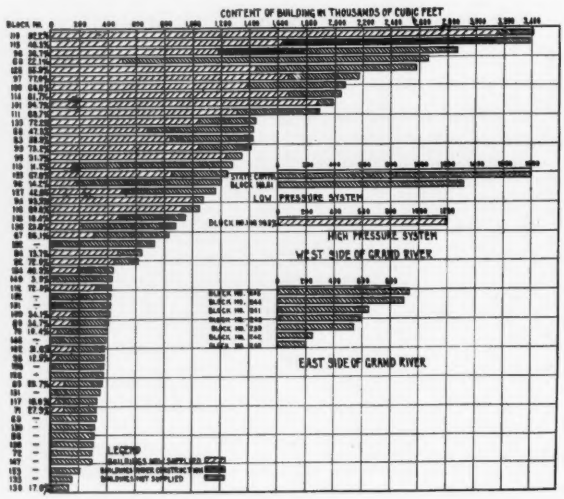

CONTENT OF BUILDING IN THOUSANDS OF CUBIC FEET
LOW PRESSURE SYSTEM
HIGH PRESSURE SYSTEM
WEST SIDE OF GRAND RIVER
EAST SIDE OF GRAND RIVER
LEGEND

FIG. 3. CHART INDICATING PROBABLE GROWTH OF LOAD

Fortunately the heat loss from well insulated underground pipes is neither proportional to the size of the pipe nor to the number of square feet of pipe surface. For example, a 12-in. pipe loses only one-fifth more heat per linear foot than a 6-in. pipe, while its carrying capacity is five and a half times greater and the cost of installation less than twice as much. From the standpoint of heat loss and carrying capacity of mains, therefore, it is not a serious disadvantage to install mains of large size than those actually required for immediate needs. The cost of installation consequently becomes the governing factor in

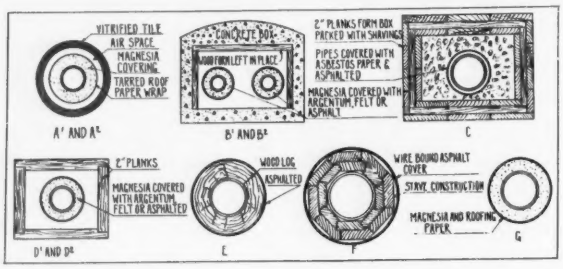


FIG. 4. MANY TYPES OF UNDERGROUND CONSTRUCTION WERE IN USE

forming any conclusion as to the extent of provision for future growth and in deciding the ultimate economic boundaries of the system.

Limit of Low Pressure Distribution

It is also obvious that there is a practicable limit to the distances at which low pressure or exhaust steam may be distributed from the source of supply and in this case the limiting factor is the maximum pressure at the service connections of customers close to the plant. This pressure limit is ordinarily from 10 to 12 lb. ga.

Taking into account the present rate of growth of the city and the fact that the development of the steam heat business was somewhat retarded for 2 or 3 yr. by the inadequate capacity of the existing mains, it was estimated that the business might reasonably be increased at the average rate of 10 to 15 per cent per annum, which in the course of 8 or 10 yr. would double the present service.

With a view to checking the reasonableness of the assumptions made of future growth, the gross cubic contents of all the present buildings within the enlarged heating zone were computed and grouped as shown in the accompanying chart, Fig. 3, which also shows the distribution of gross and heated space by city blocks. This chart shows that over 48 per cent of the gross space is now heated in the zone on the west side of the river. These figures do not include new buildings under construction, which were finished in 1924 and 1925 and certain buildings such as the state capitol, the high school and library, which, if connected to the present system, as formerly, would add over 180,000 sq. ft. of radiation to the present total of 375,000; representing thereby an addition of 50 per cent.

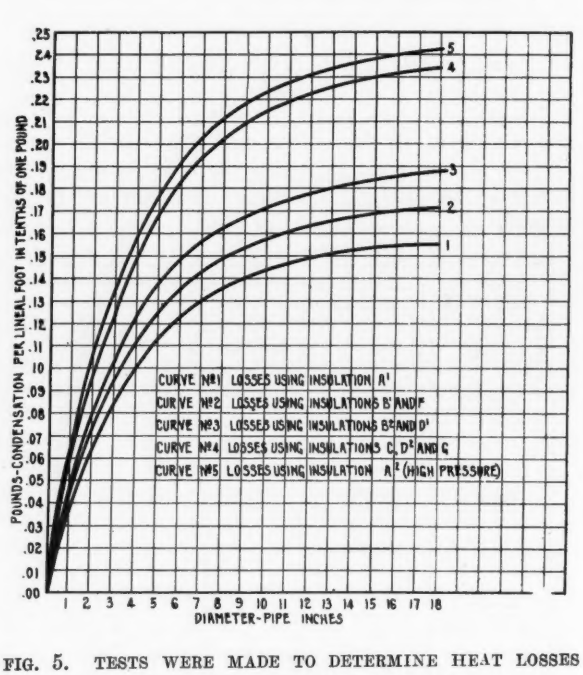

POUNDS-CONDENSATION PER LINEAL FOOT IN TENTHS OF ONE POUND
DIAMETER-PIPE INCHES
CURVE №1 LOSSES USING INSULATION A'
CURVE №2 LOSSES USING INSULATIONS B' AND F
CURVE №3 LOSSES USING INSULATIONS B² AND D'
CURVE №4 LOSSES USING INSULATIONS C, D² AND G
CURVE №5 LOSSES USING INSULATION A² (HIGH PRESSURE)

FIG. 5. TESTS WERE MADE TO DETERMINE HEAT LOSSES FROM VARIOUS TYPES OF INSULATION

Existing steam heat loads were first determined at various points on the system. With this as a basis, together with a survey of the residence and other blocks not served with steam heat in the heating zone, estimates were made showing the approximate distribution of the steam heat loads at the end of the 10 yr. period as nearly as they could be predicted in advance. Detailed computations were then made, to determine the proper size of pipe and the drop in steam pressure at each street intersection. The main purpose of this investigation was to determine what changes, if any, should be made in the existing system to provide for the future growth as outlined with a maximum drop in pressure from plant to service connection of 5 to 6 lb. The entire system as re-designed on this basis is shown on the map, Fig. 2.

Careful consideration was given to the renewal of parts of the piping system which had been in use in some cases for more than 20 yr. Special attention was given where the insulation had deteriorated. At the time the study was made, many types of underground construction were in use. They were divided for the purposes of heat analysis, in accordance with the following description in which references are made to Fig. 4, showing sketches of each type of insulation. These may be described as follows: (A1) Vitrified tile, steel pipe covered with magnesia, wrapped with 60-in. roofing paper, for low pressure. (A2) Same as A1 except for high pressure service. (B1) Wrought iron pipe, magnesia covered with felt, argentum or asphalted, enclosed in concrete. (B2) Same as B1, except using cast-iron universal pipe. (C) Schott Insulation, pipe covered with asbestos paper, 3 ply, and asphalt coated. Enclosed in plank constructed box filled with shavings. (D1) Wrought iron pipe covered with magnesia, wrapped with argentum, felt or asphalt coated and enclosed in 2-in. plank constructed tarred box. (D2) Same as D1 only using cast-iron universal pipe. (E) Pipe enclosed in wood log which is asphalt coated. (F) Pipe enclosed in wood stave construction covering which is wire bound and asphalted and (G) Pipe is magnesia covered

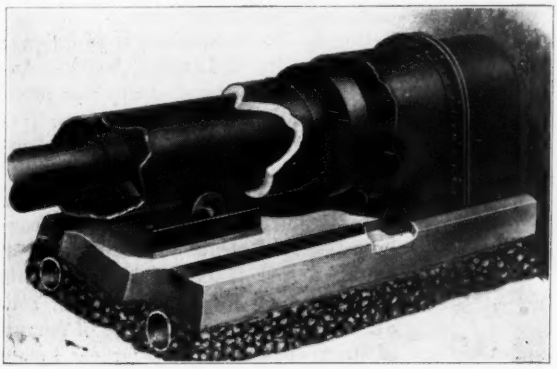


FIG. 6. HIGH-PRESSURE LINE INSTALLED INSIDE OF LOW-PRESSURE PIPE

and wrapped with roofing paper, no other enclosure or insulation. Heat losses for the types of underground construction described above are shown in Fig. 5. Notwithstanding the relatively poor quality of insulation and construction of portions of the underground system, the heat loss in the trunk mains and branches was found to be less than 5 per cent of the full load by estimating that 0.24 lb. of steam was required per hr. per sq. ft. of radiation in the buildings served and that approximately 80 B.t.u. was lost per sq. ft. of radiating service by the mains and branches.

High Pressure Line Inside of Low Pressure Pipe

By a somewhat novel method of construction, as shown in Figures 6 and 7, the new main which was run from the station at Ottawa St. to the intersection of Washington Ave. and Washtenaw St., the steam carrying capacity was greatly increased and the heat losses reduced to about 25 per cent of that obtained in former work by installing a new high pressure booster line inside of the low pressure exhaust steam main, which tapered in size from 18 in. to 10 in. in diameter. The inner high pressure steam main, which can be operated up to 175 lb. pressure, is supported in alinement guides in the interior of the low pressure pipe and the outer main is installed with magnesia insulation and roofing paper outer covering, all as shown on Fig. 6. The low pressure main was fabricated with Vanstone square lap joints with duplex corrugated copper gaskets and rolled steel flanges. Rolled steel flanges of the high pressure type were used and all flanges and fittings as well as the body of the pipe were thoroughly insulated so as to reduce the heat losses from these parts to a minimum.

Provision for the additional expansion in the high pressure main above that in the low pressure main was made at

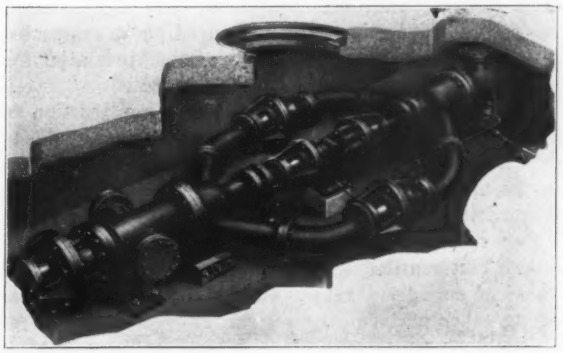


FIG. 7. PROVISION FOR EXPANSION WHERE ONE PIPE IS INSIDE THE OTHER

the manholes as indicated in Fig. 7. The problem of providing means for expansion where one line was run inside the other was a difficult one and required an expansion joint of elaborate design. As shown in Fig. 7, it consists of three branches, the center one being the high pressure line while the two outer branches carry low pressure steam. At these points outlets were provided at the anchorage points of

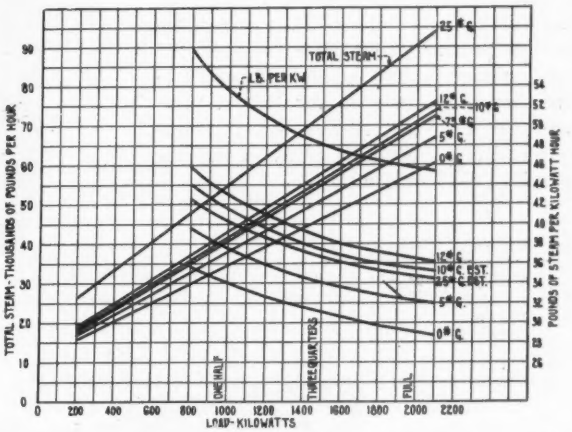


FIG. 8. CHARACTERISTIC CURVES OF A NON-CONDENSING TURBINE

the high pressure main from which steam could be admitted either through a reducing valve into the low pressure main or supplied to customers on the route of the main who desired to secure high pressure steam for laundry or kitchen purposes.

The low pressure main is drained back to the generating station through low pressure traps and the high pressure booster, inside the low pressure main, is drained by

high pressure traps into the low pressure main. Temperature differences flash the high pressure condensation into steam in the low pressure main. During the last heating season, the exhaust steam delivered to the low pressure main was superheated about 25 deg. The high pressure main was concentric with the low pressure main for a distance of about 2100 ft. A new type of conduit was used for this part of the re-construction work, consisting of a U-shaped steel section conduit joined by bolted angle-iron flanges with a Bitumastic gasket in between to provide for expansion. The lower flanges of the conduit were recessed in a groove in the conduit and filled in with a special plastic waterproof compound. The steel conduit proper, after fabrication with its flanged ends, was coated with a Neumastic compound at high temperature after the metal had been previously cleaned and heated.

Every care was taken in the course of construction to provide a rigid concrete base, properly drained and to secure a perfect alinement of both the high and low pressure mains on the special adjustable roller supports. Expansion joints were of the crosshead guided-slip type.

Two openings were provided in all important manholes so that ventilation by a special fan could be secured in case of emergency repair work. In replacing and extending other parts of the system, two general types of construction were adopted. One, a concrete box somewhat similar to that shown at A, and second, that shown at B in Fig. 4. On the new work, even on the low pressure piping system, steel flanges were used and on the larger size, Vanstone joints and rolled steel flanges were used.

Joints Were Cemented

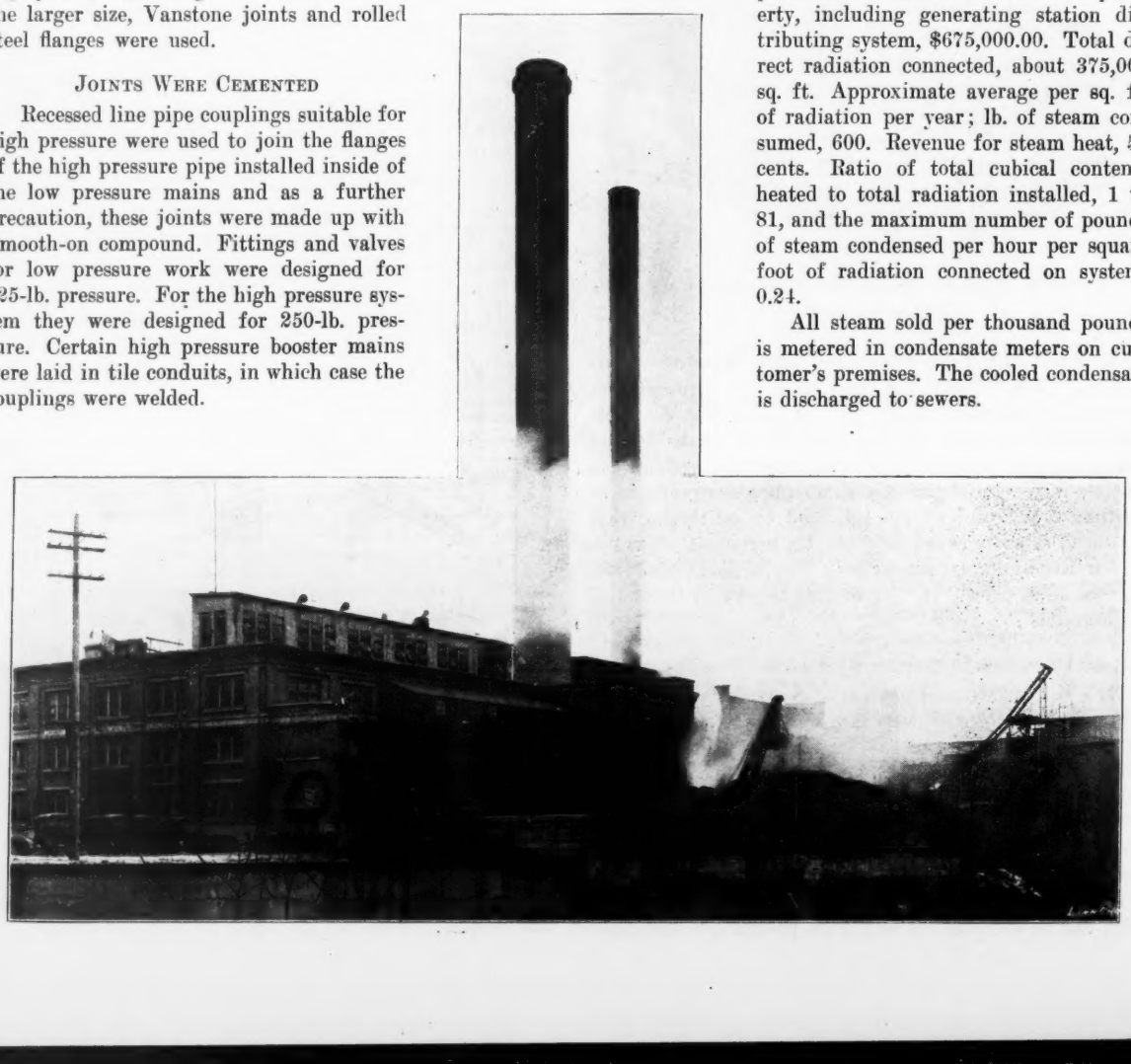
Recessed line pipe couplings suitable for high pressure were used to join the flanges of the high pressure pipe installed inside of the low pressure mains and as a further precaution, these joints were made up with Smooth-on compound. Fittings and valves for low pressure work were designed for 125-lb. pressure. For the high pressure system they were designed for 250-lb. pressure. Certain high pressure booster mains were laid in tile conduits, in which case the couplings were welded.

Care was taken to secure proper drainage, which in most cases was counter to the steam flow, because the system as a whole is at a higher elevation than the station. Where space conditions would permit and the high pressure lines were run singly, expansion pipe bends or loops were used instead of the slip type of joints, in order to reduce maintenance. Before the trenches for the new work were filled, the new pipe work was thoroughly tested, both hydraulically and by steam, under pressures two to three times that for which the system was designed.

All of the exhaust steam available at the Ottawa St. Station is utilized in the heating system and this is supplemented by live steam for delivery to the more distant points of the system, the pressure being regulated at the station to meet the daily requirements. The steam heat system is credited with the value of the electric current, generated in non-condensing turbo-generators, at a rate corresponding to the cost at the switchboard at the new Municipal electric generating station at Moores Park. Electric current generated by turbines from which the exhaust steam is distributed and sold is considered the by-product from the standpoint of accounting, thus simplifying the segregation of costs in a combined heat, light and power station. Figure 8 shows the characteristic performance curves of a special non-condensing turbo generator when operated under various back pressures.

General data relating to this installation is as follows: Approximate population of City of Lansing, 80,000. Approximate valuation of steam-heat property, including generating station distributing system, $675,000.00. Total direct radiation connected, about 375,000 sq. ft. Approximate average per sq. ft. of radiation per year; lb. of steam consumed, 600. Revenue for steam heat, 59 cents. Ratio of total cubical contents heated to total radiation installed, 1 to 81, and the maximum number of pounds of steam condensed per hour per square foot of radiation connected on system, 0.24.

All steam sold per thousand pounds is metered in condensate meters on customer's premises. The cooled condensate is discharged to sewers.



Burning Natural Gas and Oil

With a Gas Well Nearby Transportation Difficulties and Miners' Strikes Are Forgotten

IN THE STATES of Kansas, Oklahoma and Texas, there is a vast amount of fuel wealth in the form of natural gas. As is well known, those states are also particularly richly endowed with petroleum. In the early days of gas well operation the wastage was almost beyond belief. Today, however, vast networks of high pressure gas pipe lines are distributing this fuel where it can be used.

The method outlined here for burning oil and gas is that employed by a municipally owned plant in southeastern Kansas. This plant has been so successful in burning those fuels that it has paid its own way, retiring old indebtedness and paying for improvements out of net earnings. The rating of the plant is about 4250 kw., the average day load being about 1200 kw.

Several years ago two new boilers were installed. They were made by the Erie City Iron Works and each was

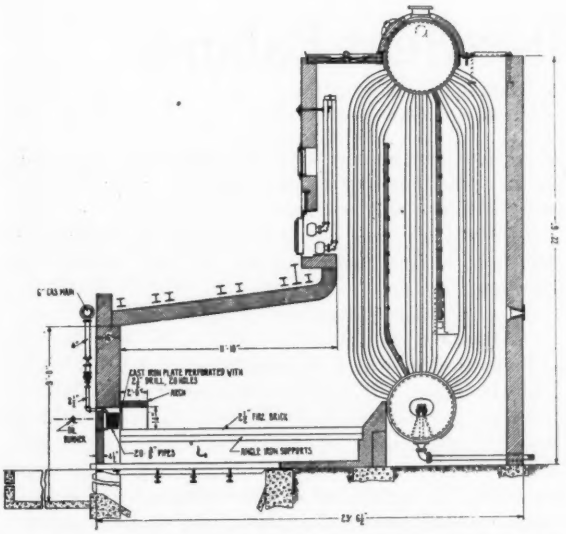


FIG. 1. AIR FOR COMBUSTION IS PREHEATED UNDER THE FLOOR OF THE FURNACE

rated at 770 hp. They were of the two-drum, bent-tube type and were set with a dutch oven furnace, 11 ft. 10 in. deep. The flat arches were of the suspended type and the Foster superheaters were set in the front wall just above the arch.

The floor of the furnace is at the level of the dead plate and is constructed of a 2½-in. layer of firebrick supported on structural angles. This leaves an open space between this floor and the boiler room floor which is used to preheat the air for combustion. This space is divided into three compartments so that air enters the two outside compartments at the front, passes to the rear and then comes forward in the center compartment. The front wall, which is 16 in. thick, is bricked up at the burners with 4½ in. of firebrick. This thin wall is flush with the outside of the furnace wall. Therefore, there is a space about 24 in. wide by 24 in. high by 12 in. deep, which is connected to the center air compartment.

Burner units, of which there are 60 for each boiler, are arranged 20 in a group. Therefore, there are three burner units which must get air from the center air compartment. Opposite each burner group and flush with the inside of the furnace front wall is a cast-iron plate which contains twenty 2½-in. holes, equally spaced over its area and also a slot in the center of the plate. Flaring out from this plate are two wing walls which are covered with tile, thus forming a small combustion space 14 in. high, 24 in. wide at the plate, 36 in. wide at the outer end and extending about 2 ft. from the inside of the furnace front wall.

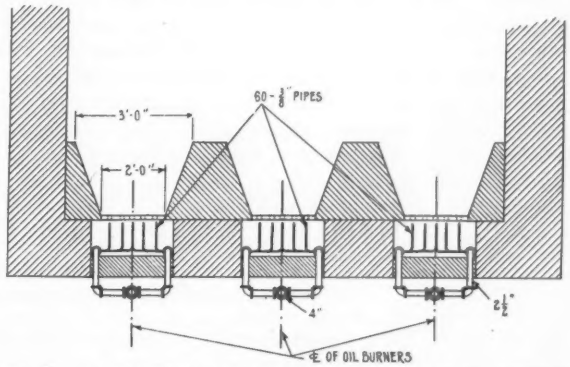


FIG. 2. OIL BURNERS ARE ARRANGED IN GROUPS OF TWENTY

Natural gas sells in that district for 20 cents per 1000 cu. ft. Therefore, it was deemed advisable to put down a well near the plant. This was done with the result that a gas well was brought in which has a static pressure of 140 lb. or when gas is flowing from it at the rate of 35,000 cu. ft. per hr., the pressure drops to 25 lb. This well has paid for itself about three times since it was placed in operation several years ago.

Purchased gas, which is required at the rate of 500,000 cu. ft. per day, reaches the plant at a pressure of 25 lb. per sq. in. The pressure is reduced to 5 lb. and it is then metered by the gas company. It is then metered again by the purchaser and is thus reduced in pressure to a few ounces per square inch. This reducing valve operates on the steam pressure, thus, by taking the base load from the municipally owned well, which it is expected will assure a long life from that well, and the fluctuations from the purchased main, a worth-while saving is made.

Connection from the municipal well to the gas main is made between the steam controlled regulating valve and the furnaces.

The gas main passes overhead at the furnace fronts. Three drop connections are made to each furnace, one for each of the burner groups. A valve is located in each drop connection. Just above each burner group is a tee, so that the drop connection splits the gas flow two ways, one connection being carried to each side of the burner group and goes through the 4½-in. brick wall in the space back of the perforated plate. These connections then drop down to the bottom of this air space and are connected by an equalizer pipe.

This construction leaves two vertical pipes in back of the perforated plate, one being on each side. Each vertical

pipe is drilled and tapped for ten ⅜-in. pipes which are directed so that each one discharges a ⅜-in. stream of gas at one of the 2½-in. holes in the plate.

Thus the air which has been heated in passing under the furnace floor is drawn into the space back of the perforated plate. It then passes through the openings in the plate with the jets of gas. The small mixing chamber in front of the plate tends to mix and preheat the mixture, so that combustion begins to take place just as the mixture reaches the end of the 2-ft. arch.

Gas pressure at the burner tips is about 8 oz. Its heat value is about 960 B.t.u. and a kilowatt-hour is produced at a cost of about 32 cu. ft. of gas. Combustion is controlled by dampers in the boiler uptake, so that normally the draft on the boiler side of the damper is 3/10 in. water and practically balanced draft is maintained in the furnace. The CO_2 will average about 10.5 per cent.

Advantages of burning natural gas are that for the present at least there is no seasonal shortage of fuel, transportation difficulties are not experienced and furnace operation requires very little attention. Further, there is no soot or slag formation on the boiler tubes; for that reason this plant is not equipped with soot blowers.

If, for any reason, there should be an interruption in the gas service, this plant has provided storage for three carloads of fuel oil. A steam coil located in the storage tank near the pump suction pipe heats the oil to about 140 deg. F. The pumps maintain a pressure of 60 lb. on the oil and it is atomized by means of steam. The oil line to the burners is not connected on a loop system. Each furnace is equipped with three oil burners. These burners are normally not in place but can be connected up quickly by screwing up two union joints on each burner.

The slot in each cast-iron plate is the opening through which the oil is sprayed. Thus the burner extends through a dampered opening in the 4½-in. brick wall and into the heated air space back of the cast-iron plate. Air for combustion is heated as was the case when the gas burners were in use. In place of 20 jets of fuel being forced in under the mixing arch there is but the one oil spray, air entering through the slot with the oil spray and also through the 20 openings through which the gas and air flowed.

Arrangement of gas burners now in use will operate the boilers, which are baffled for three passes of the gas, at from 125 to 150 per cent of load.

Simplifying the Boiler Heat Balance

Unavoidable Inaccuracies Destroy Value of Extreme Refinements. By J. R. Darnell

IF A SCIENTIST wishes to verify the atomic weight of an element, measure the speed of light or determine the specific heat of a gas, great care and delicate apparatus must be used but, if a combustion engineer has occasion to conduct a commercial evaporative test of a boiler, he should realize his limits of accuracy and not attempt to read instruments in hundredths or tenths of a unit when unavoidable errors limit the accuracy of such readings to whole units.

It is not the purpose of this article to go into detail in discussing the numerous small errors which creep into the taking of the data but rather to point out how the methods employed by many engineers in computing a heat balance may be simplified. The old axiom that a chain is no stronger than its weakest link may well be applied to the accuracy of the data of a boiler test.

It may be well to call attention to the views of no less an authority than the late Alfred Cotton who pointed out that, in addition to numerous minor errors, the accuracy of boiler tests is limited by such appreciable errors as the obtaining of the heat value of the coal burned, which may easily reach 2.5 per cent in either direction. The water evaporated may be at least 1 per cent out of the way, hence the efficiency reported may be 3.5 per cent too high or low.

Competition Cause of Absurd Guarantees

Engineers who have had experience in boiler testing will verify these statements, yet often in commercial practice all the data will be taken and all the intricate calculations made which are suited for the most exacting research tests.

Time was when it was not unusual to see a contract wherein the overall efficiency of stoker, furnace and boiler was guaranteed to tenths of a per cent, the test to be in strict accordance with all specifications of the A. S. M. E. test code and, naturally, the purchaser generally insisted on a strict compliance with all conditions. The manufacturer was imposing a heavy handicap upon himself by such guarantee and penalizing his apparatus for a condition for which no one should be blamed. It should be reasonable to allow a margin or 1½ to 2 per cent in either direction.

Heat Balance a Misnomer

With these conditions in mind, it is both justifiable and practicable, where a so-called heat balance must be made, to simplify the usual items as much as possible. For, after all, a "heat balance" is not a balance in the true sense but merely a statement of various items of heat loss and the heat recovered which, when added together, must total 100. It cannot be a true "balance" unless all the items are definitely known from actual observation.

One of these items, usually termed "radiation and unaccounted for," is never definitely known, since no satisfactory means has ever been devised for measuring the heat lost by radiation. Even if such means should be discovered, it is doubtful whether an exact balance can ever be effected. Errors in the observation of data will always alter the various items from their true value so that, even if the loss to radiation was definitely known to be 5 per cent, it would be the merest chance that the sum of all the items would equal 100.

In reality, errors are both positive and negative. If they are all positive, the sum of all the items, except radiation, will sometimes almost equal 100, or, if they tend to be negative, these items often add up to less than 90. In general, the item called "radiation and unaccounted for" will vary between 8 per cent with light loads to 4 per cent with heavy loads. Once in a great while, the positive and negative errors happen to balance each other but there is never any assurance that this will happen.

Heat balance, so-called, is then nothing more than a rough check on the various items of loss and gain and the

importance so often attached to it is not warranted. The official method of heat balance, as recommended by the A. S. M. E. Power Test Code, comprises eight items and is as follows:

	B.t.u.	Per cent
1. Heat absorbed by boiler		
2. Loss due to moisture in coal		
3. Loss due to water formed by burning hydrogen in coal		
4. Loss due to moisture in air		
5. Loss due to heat carried away in dry flue gas		
6. Loss due to carbon monoxide		
7. Loss due to combustible in ash and refuse		
8. Loss due to unconsumed hydrogen and hydrocarbons, radiation and unaccounted for		
Total heat value of 1 lb. of coal		100

It is often advisable to determine the various items of loss, as well as the efficiency, in order to know which ones are excessive and so take steps to reduce them. If the investigation is carried on with that purpose in mind, then for ordinary commercial work the foregoing heat balance may be simplified by combining items 2 and 3, also by eliminating item 4, as the last mentioned is generally less than half of one per cent, while the main item, 1, may be in error by 2 to 3 per cent. For determining the hydrogen loss, the formula is exactly the same as for determining the loss due to the moisture, with the exception that, in the latter, the value of the moisture is used while in the former, nine times the amount of hydrogen is used. By combining items 2 and 3, we can express the loss as follows:

Loss in B.t.u.
$= 9H_2 + M\,[(212 - t) + 972 + 0.47\,(T - 212)]$
M = per cent moisture in fuel.
H_2 = per cent hydrogen in fuel.
t = temperature of room, deg. F.
T = flue gas temperature, deg. F.
972 = latent heat of water vapor.
0.47 = mean specific heat of water vapor.

Since it is the evaporation of the amount of water formed by the burning of the hydrogen which causes the loss, this hydrogen value must be expressed in terms of the water which it will produce. In the equation:

$$2\,H + O = H_2O$$
$$2 + 16 = 18$$

each hydrogen atom has an atomic weight of 1 and the oxygen 16, so that when the hydrogen and oxygen combine, the molecular weight of water is 18. Therefore, in any unit weight of water, the hydrogen is in the ratio of 2 to 18, or is 1/9 of the water. Accordingly, in the above formula, 9 times the hydrogen is the equivalent of the amount of water it will produce when burned.

After the burning of the hydrogen, the evaporation of the water formed carries away a certain amount of heat and constitutes a loss. By adding this water to that already found in the coal a single item of loss may be calculated. A certain amount of sensible heat is lost in heating this water from the temperature of the air to the boiling point of water. Then approximately 972 B.t.u. must be added for evaporation and finally 0.47 B.t.u. for each degree the water vapor is superheated, that is, raised above the boiling point of water to the final flue gas temperature.

It might also be pointed out that the care taken by some engineers to read the barometer to the hundredth of an inch, in order to correct the boiler gage pressure to absolute pressure, is wasted effort. Also that it is unnecessary to read the total heat in the steam (from steam tables) closer than to the nearest whole number.

If the normal barometer reading at elevations from sea level to 750 ft. is taken as 15 lb. per sq. in., at 750 to 1500 ft. as 14 lb. per sq. in., at 1500 to 2250 ft. as 13 lb. per sq. in., results of the final calculations will be just as accurate as other conditions will permit. A difference of 1 lb. in the atmospheric pressure will show a difference of only 1/10 B.t.u. in the total heat in the steam.

In the determination of item 5, showing the loss due to the heat carried away in the dry flue gas, the number of pounds of dry gas per pound of fuel must be first obtained. The formula generally given for this is as follows:

$$\text{Lb. gas} = \frac{11\,CO_2 + 8\,O_2 + 7\,(CO + N_2)}{3\,(CO_2 + CO)} \times (\text{per cent carbon in fuel})$$

This may be simplified to a statement much easier to remember and easier to calculate. Formulas for determining the various items of loss are found in all books on combustion or power plant practice and are generally used as given but observation has shown that authors sometimes fail to state and use them correctly, probably because of lack of understanding of the construction of such formulas.

In presenting a simpler statement for the foregoing formula, it may be of interest to show its derivation and the steps leading up to the development of the simpler form.

Derivation of Formula for Dry Gas Loss

Dry gas per pound of carbon times the weight of carbon burned per pound of fuel equals the total dry gas, or

$$\text{Dry gas per pound carbon} = \frac{\text{Total dry gas per pound fuel}}{\text{Weight of carbon burned per pound fuel}}$$

Expressed in per cent,

$$\left.\begin{matrix}\text{Dry gas} \\ \text{per lb. C}\end{matrix}\right\} = \frac{100}{(\text{per cent C in } CO_2) + (\text{per cent C in CO})}$$

Since the molecular weight of CO_2 is 44 and that of carbon is 12, then 12/44 of the CO_2 is carbon and 12/28 of the CO is carbon. Accordingly, the above equation may be expressed:

$$\text{Dry gas per lb. C} = \frac{100}{12/44\,(CO_2) + 12/28\,(CO)}$$

Since 100 is the sum of the total dry products of combustion, $CO_2 + O_2 + CO + N_2$, then we may express the preceding equation in this manner:

$$\text{Dry gas per lb. C} = \frac{CO_2 + O_2 + CO + N_2}{12/44\,(CO_2) + 12/28\,(CO)}$$

But since, in commercial practice, flue gas analysis is almost always volumetric, this last equation must be reduced to volumetric form.

This may be done by multiplying the value of each gas by its molecular weight:

$$\text{Dry gas per lb. C} = \frac{44\,CO_2 + 32\,O_2 + 28\,CO + 28\,N_2}{12\,CO_2 + 12\,CO}$$

Reducing to lowest terms,

$$\text{Dry gas per lb. C} = \frac{11\ CO_2 + 8\ O_2 + 7\ CO + 7\ N_2}{3\ CO_2 + 3\ CO}$$

$$= \frac{11\ CO_2 + 8\ O_2 + 7\ (CO + N_2)}{3\ (CO_2 + CO)}$$

This is the formula used in the majority of textbooks but it can be made much simpler, consequently, easier to remember. Since the per cents of CO_2, O_2, CO and N_2 always total 100, either by weight or volume, we will have:

$$CO_2 + O_2 + CO + N_2 = 100 \qquad (1)$$

and, if we let X be the dry gas per lb. of carbon, then

$$11\ CO_2 + 8\ O_2 + 7\ CO + 7\ N_2 = X \qquad (2)$$

We can eliminate values of CO and N_2 by multiplying equation (1) by 7 and then subtracting (1) from (2), thus

$$11\ CO_2 + 8\ O_2 + 7\ CO + 7\ N_2 = X$$
$$7\ CO_2 + 7\ O_2 + 7\ CO + 7\ N_2 = 700$$

$$4\ CO_2 + O_2 = X - 700$$

Transposing we have

$$4\ CO_2 + O_2 + 700 = X \qquad (3)$$

Since things equal to the same thing are equal to each other, equations (2) and (3) are equal, hence

$$11\ CO_2 + 8\ O_2 + 7\ CO + 7\ N_2 = 4\ CO_2 + O_2 + 700$$

We can then substitute the expression $4\ CO_2 + O_2 + 700$ for its equivalent and the formula for determining the dry gas per pound of carbon will then read:

$$\text{Dry gas per lb. C} = \frac{4\ CO_2 + O_2 + 700}{3\ (CO_2 + CO)}$$

In practical operation, the fuel used is never all pure carbon, so that expressing the formula in terms of the particular fuel used, we will then have the equation:

$$\text{Dry gas per lb. fuel} = \frac{4\ CO_2 + O_2 + 700}{3\ (CO_2 + CO)} \times \left\{ \begin{matrix} \text{per cent} \\ \text{C in fuel} \end{matrix} \right.$$

$$\text{Loss in B.t.u.} = W \times 0.24\ (T - t)$$

where,

W = dry gas per lb. fuel

0.24 = mean specific heat of flue gas

T = temperature of flue gas, deg. F.

t = temperature of room, deg. F.

$$\text{per cent loss} = \frac{\text{Loss in B.t.u.}}{\text{B.t.u. in fuel}}$$

Confusion in Determination of Ash Loss

Confusion seems to be caused by misunderstanding of the terms ash and refuse. By ash is meant the per cent of true ash in the dry coal by proximate analysis. By refuse is meant the amount of material, including true ash, unconsumed carbon, and coal, removed from the ash pit during the test.

If such material is removed and weighed dry or its weight calculated on a dry basis and a sample then taken and analyzed for the amount of carbon it contains, the loss may be expressed as follows:

$$\text{Loss in B.t.u.} = C \times R \times 14{,}600$$

where,

C = per cent carbon in the dry refuse

R = weight of dry refuse in per cent of dry coal fired

14,600 = heat value of 1 lb. carbon.

If, however, a test is made and the refuse is not weighed, but a sample is taken and analyzed for its carbon content, then in order to determine the loss, it is necessary to know the per cent of true ash in the dry coal. The loss under these conditions is stated in this manner:

$$\text{Loss in B.t.u.} = \frac{C \times A}{1 - C} \times 14{,}600$$

where,

C = per cent carbon in dry refuse

A = per cent true ash in dry coal fired

Hydrogen and Hydrocarbons in Flue Gas Doubtful.

In modern boiler settings, it is extremely doubtful whether any of the losses attributed to item 8 of the A. S. M. E. balance are caused by unconsumed hydrogen and hydrocarbons. Expert investigation, particularly research tests by the Bureau of Mines, has shown that such combustible gases seldom, if ever, reach the flue without being burned. With coal, the only hydrocarbon found in an appreciable amount is methane and this only at or near the surface of the fuel bed. In spite of its being a saturated compound, it is unstable and, if it does not burn completely, will break down into carbon and hydrogen. The carbon so formed may burn to carbon monoxide or to carbon dioxide or it may pass out of the furnace unburned in the form of soot. Hydrogen will burn even more readily than carbon monoxide, so that, by the time the gases leave the furnace, if there is any combustible left, it will most likely be carbon monoxide. It is possible for a small amount of hydrogen to escape but the chances are slight.

"Radiation and Unaccounted for" Not Accurate

In conclusion, then, it may be stated that the losses as ordinarily listed under item 8 are largely, if not all, due to radiation and an accumulation of errors in the observation of data and should be so rated as " Radiation loss and net of errors in observations."

It might be even better to give up trying to make all items total 100 and let the sum of the determined items stand as the heat accounted for, the remainder to be understood as being taken care of by unavoidable errors in data and by losses which cannot be measured.

Ingenuity and initiative were displayed by George Hargett of Hutchinson, Kan., when he was instructed to load a 10,000-lb. boiler on his truck for a Fourth of July parade. He laid a wager that, unaided, he would get the boiler which was at an oil well some 12 mi. from the city and return within 3 hr. and a timekeeper was agreed on. He won the wager with 3 min. to spare, in spite of the fact that he was held up several minutes at a railroad crossing. This is his story of how he did the trick:

"The boiler was standing on its bottom, dome up, just as it was left when work stopped. I backed the truck up to one side and took a chain hitch from the truck to the dome. Driving the truck forward pulled the boiler partly over and I put blocks under the high side. Then I backed up on the other side and repeated the operation and rocked the boiler back and forth until it was high enough and level. Then I drove the truck up alongside, put a chain around the boiler to give a rolling hitch and, by means of two stakes in the ground and chain falls, rolled the boiler over onto the truck and trailer.

"It's no trick when you know how."

Unit System of Pulverizing and Burning Coal

INCOMPLETE COMBUSTION AND EXCESS AIR PROBLEMS SOLVED BY USE OF PULVERIZED COAL. BY W. C. HECKEROTH*

SINCE FUEL cost ranges from 50 to 85 per cent of the total cost of making steam in the industrial plant, the proper place to start reducing costs is at the coal pile. The object of this paper is to point the way to realizing savings far greater than can be effected in any other single item of expense connected with the operation of the average industrial plant.

Coal, our principal source of energy, must be burned to release its energy for conversion into work. In the burning of any fuel there are certain unavoidable losses of the energy or heat units stored within it. These losses are due to radiation, evaporation of the moisture in the fuel, heat carried up the chimney in the waste gases, etc. In the development of the art of fuel combustion, attention has been focused on furnace design, improvements in grates, both stationary and mechanically operated, insulation of furnaces and settings, etc.

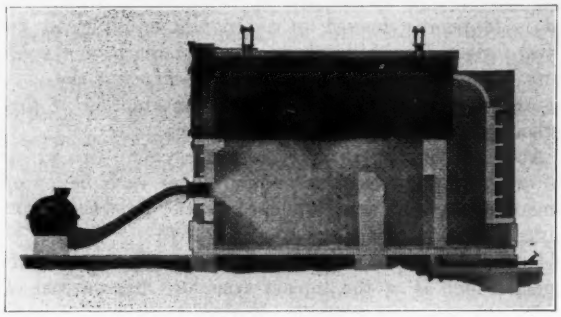


FIG. 1. UNIT SYSTEM IS APPLICABLE TO MANY EXISTING HAND FIRED INSTALLATIONS

In the burning of coal on grates, however, there has been for many years, and is now, an enormous waste of fuel due to two principal causes:

1st. Incomplete combustion.

2nd. Amount of excess air used.

Incomplete combustion is represented in part by the presence of combustible matter in the ash, which in the case of the average hand fired furnace may run anywhere from 25 to 40 per cent of the weight of ash and refuse and, in the case of stoker fired furnaces, from 15 to 25 per cent. These figures may be greater or less in some instances depending upon the skill of the individual fireman, the quality of coal burned and upon the type of grate or stoker used.

Another evidence of incomplete combustion is the deposit of soot on the heating surfaces of the boiler and the discharge of smoke from the chimney. This is due to the heavy hydro-carbon gases which are the first to leave the coal, failing to combine with the necessary oxygen before these gases reach a zone in the boiler or other apparatus, where it is too cool for combustion to take place.

There may also be present in the chimney gases an invisible gas known as carbon monoxide which also results from improper mixing and failure of the necessary oxygen to combine with the carbon under proper temperature conditions to effect complete combustion.

*Engineer, Erie City Iron Works.

Theoretically a pound of good coal requires approximately 11.5 lb. of air, to supply the oxygen necessary to combine with the carbonaceous matter of the coal to effect complete combustion, represented by carbon dioxide or CO_2. When more than this theoretical amount of air is used, the excess carries with it as it leaves the chimney at a temperature of from 500 to 650 deg. F., a large number of heat units that are lost to useful work.

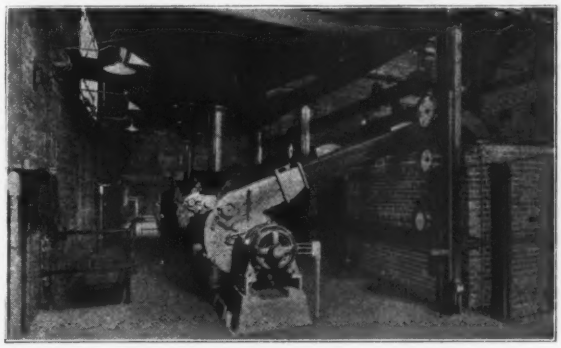


FIG. 2. IN THIS PLANT ARE TWO 250-HP. VERTICAL WATER-TUBE BOILERS SERVED BY THE UNIT SYSTEM OF POWDERED COAL EQUIPMENT

It is impossible in practice to burn coal to complete combustion without the use of some excess air. Reasons for this will be given later. The aim should be to liberate all of the heat units in the coal, using as low a percentage of excess air as possible.

STRATIFICATION OF GASES MAY OCCUR

It is extremely difficult, when burning coal in lump form on grates of any kind, to mix intimately with the gases leaving the fuel bed, the air which is drawn through the grates by natural draft or blown through by a forced draft fan. This is because coal does not burn uniformly on grates, due sometimes to an uneven thickness of fuel bed or to clinkers and slag obstructing the passage of the air. As a result, stratified streams of rich and lean gases rise from the fuel bed and pass on their way to the chimney without properly mixing to effect good combustion.

Also, what are termed holes occur in the fuel bed, due to more intense combustion at some spots than at others and through these holes large amounts of excess air enter the furnace, absorb heat and carry it out the chimney without having accomplished any useful work. The more or less frequent opening of firing doors and cleaning doors also admits large quantities of excess air.

As a result of these conditions, it is often found upon analyzing the chimney gases that from 50 to 150 per cent more air has entered the furnace than is theoretically required.

Therefore the problem of the combustion engineer has been to eliminate, as far as possible, these two principal sources of loss of the heat energy of the coal, namely, incomplete combustion and excess air. In the solution of this problem, the unit system of preparing and burning pulverized coal has been developed.

DATA AND RESULTS OF EVAPORATIVE TEST

Tests of Erie City Vertical Water Tube Boiler and Erie City Pulverized Coal Equipment, located at New York & Pennsylvania Co. Paper Mill, Johnsonburg, Pa., to determine efficiency and capacity. Conducted by R. H. Jones (New York & Pennsylvania Co.) and W. C. Heckeroth (Erie City Iron Works).

Kind of furnace: pulverized coal	
Kind and size of coal: Pennsylvania Bituminous - Reynoldsville District - Run of Mine.	
Size of coal after crushing: passed through 1¼ in. mesh	
Water heating surface of boiler, sq. ft.	9,907
Heating surface - water screen, sq. ft.	290
Total water heating surface, sq. ft.	10,197
Superheating surface	None
Date	1-12-24 to 1-13-24
Duration	25.25 hr.

Average Pressure, Temperatures, Etc.

Steam pressure by gage, per sq. in.	139 lb.
Atmospheric pressure (altitude 1450 ft.)	14.17 lb.
Absolute steam pressure, per sq. in.	153.17 lb.
Temperature of gases leaving boiler	567
Temperature of feed water entering boiler	165
Factor of evaporation	1.0933
Draft in furnace	.06
Draft at boiler outlet	.29
Percentage of moisture in steam	1.26

Total Quantities

Weight of coal as fired	141,416 lb.
Percentage of moisture in coal as weighed*	4.91
Weight of dry coal consumed	134,473 lb.
Percentage of ash in dry coal	8.83
Total weight of ash in dry coal	11,874 lb.
Weight of water fed to the boiler	1,446,839 lb.
Weight of water evaporated, corrected for moisture in steam	1,428,609 lb.
Equivalent evaporation from and at 212 deg. F.	1,561,898

Hourly Quantities and Rates

Moist coal consumed per hr.	5,600 lb.
Dry coal consumed per hr.	5,326 lb.
Water evaporated per hr., corrected for moisture in steam	56,578
Equivalent evaporation per hr. from and at 212 deg. F.	61,857

Capacity

Boiler hp. developed	1793
Rated capacity in b.hp. (including water screen)	1019
Percentage of rated capacity developed	176

Economy Results

Water fed per lb. coal as fired	10.23
Water evaporated per lb. dry coal	10.62
Equivalent evaporation from and at 212 deg. F. per lb. dry coal	11.61
Equivalent evaporation from and at 212 deg. F. per lb. combustible	12.74

Efficiencies

Calorific value of 1 lb. dry coal - B.t.u.	14,033
Overall boiler efficiency	80.3
Lb. of coal as fired per b.hp. per hr.	3.12
Lb. of dry coal per b.hp. per hr.	2.97
Average CO_2 in stack gases, per cent	13.7

Power Consumed in Preparing Coal

Average kw. per T. moist coal crushed, conveyed, elevated and distributed in coal bunker	0.3
Average kw. per T. moist coal pulverized	16.4
Average total kw. per T. moist coal fired	16.7
Coal as pulverized - per cent of pulverizer capacity	62.2
Cost of electric power per kw.-hr.	.01¢
Cost of power per T. moist coal in bunker	.3¢
Cost of power for pulverizing 1 T. moist coal	16.4¢
Total cost of power for preparing 1 T. of moist coal for firing	16.7¢
Furnace volume above water screen, cu. ft.	4,911
Lb. of moist coal burned per cu. ft. per hr. furnace vol.	1.14
Lb. of dry coal burned per cu. ft. per hr. furnace vol.	1.08
Cu. ft. furnace vol. per hp. developed	2.73

Proximate Analysis of Coal

Moisture, per cent	4.15
Volatile, per cent	29.06
Fixed carbon, per cent	57.36
Sulphur, per cent	.97
Ash, per cent	8.46
Total	100.00
B.t.u. per lb. (Dry)	14,033

* Coal as fired had somewhat less moisture due to drying out slightly in bunker.

Coal, like any material which is naturally inflammable, becomes much more so when pulverized to a finely divided state. This is easily understood when it is realized that combustion is a surface reaction and pulverizing increases immensely the surface exposed to oxidation.

Coal in pulverized form was first burned successfully in the cement industry, some 25 or 30 yr. ago and its advantages and economy were quickly realized. When the application of this fuel to boilers was first attempted, considerable trouble was experienced due to failure of the furnace refractories and to melting of the ash, forming a slag which it was difficult to remove from the furnace. This was because it was not realized that ordinary furnaces as used with grates were not of proper design to permit of good combustion of pulverized coal or for the disposal of the ash in a manner to prevent slag.

Much research and development work has been carried on during the past years, with the result that now the use of pulverized coal under boilers has not only passed out of the experimental stage but is being adopted generally for firing boilers from 100-hp. size up to the largest units built.

Two distinct systems for pulverizing and firing pulverized coal are in common use today. One is usually referred to as the "central" or "storage system" and the other the "unit system."

Usually the "storage system" requires that the coal be first dried and after it passes through pulverizers, exhausters, cyclone separators and a conveying system, it is delivered in powdered form to bunkers or bins from which it is fed by additional conveyors to the burners. This system involves the use of considerable equipment, and is frequently housed in a separate building, at an initial investment which places it out of reach of a great many plants where the space requirements and the capital expenditure would not warrant the adoption of this method of firing coal.

About 5 or 6 yr. ago, a unit system, in which one or more pulverizers are employed at each boiler or furnace to be fired, was developed by the Erie City Iron Works.

In this system a dryer is not required, as the pulverizer, which is of the impact type, will handle coal of almost any moisture content. Eastern coals will average from 3 to 5 per cent moisture, while Midwestern and Western coals contain from 10 to 15 per cent, and lignite from 25 to 35 per cent moisture. The major portion of the moisture in lignite and other high moisture coals found in the Western states, is of an inherent nature and does not affect to an appreciable extent the capacity of the pulverizer. Only in cases of extreme surface moisture is the capacity reduced somewhat.

Coal fed to the unit pulverizer should be of a size not exceeding 1½ in. and should be fed over a magnetic separator to remove tramp iron such as bolts, nuts, pick points and chisels. The magnetic separator can be located either at a point between the coal crusher and the elevator which supplies the usual coal bunker or it may be suspended directly under the bunker and fed into small hoppers over the pulverizers. Various arrangements are adopted to meet local conditions.

After being crushed to proper size and freed of tramp iron, the coal is fed direct to the pulverizer where it is reduced to proper fineness and thoroughly mixed with the air for combustion by a fan which is an integral part of the pulverizer and which discharges this mixture direct to the furnace ready for instant combustion.

No hopper or bin of any kind is used between the pulverizer and the furnace, the coal being pulverized at a rate to meet load conditions. The amount of coal entering the pulverizer is easily controlled by a simple feeding device to meet requirements and the admission of combustion air at the fan inlet of the pulverizer is also controlled by adjustable registers. Both coal and air supply can be automatically controlled if desired. The pul-

verizers are usually arranged for direct motor drive, a flexible coupling being used between the pulverizer and motor.

Where the exhaust steam can be used in process work or for heating purposes, a steam turbine is used. In this case, either a slow speed turbine is direct connected or a high speed machine is used with reduction gears.

Thorough mixing of the coal and air before the fuel is fired, makes it possible to burn the coal with an amount of air only slightly in excess of that theoretically required. This, together with the fact that it is not necessary to open doors frequently for firing or cleaning fires and ash pits, eliminates to a large extent one of the big losses incident to firing coal in lump form.

Exceedingly rapid combustion resulting from firing coal in powdered form and the intimate mixing of the coal and air before firing makes possible the elimination of the second big loss common in other methods of firing coal, namely, that due to incomplete combustion. The loss of combustible in powdered coal firing is usually less than half of one per cent.

Saving in fuel and labor will in most cases pay for the complete equipment in from 12 to 18 mo. Generally speaking, this system can be profitably installed wherever the coal or other fuel consumption is equivalent to 2000 T. or more per year. The requirements of this system are so few and simple that there are not many plants where the costs of producing steam and power cannot be materially reduced, in many cases 25 to 35 per cent.

In summarizing the principal reasons why coal should be burned in pulverized form we have:

(1) That it is possible to make a saving in fuel that will pay substantial returns on the moderate investment involved.

(2) A considerable saving in labor can usually be accomplished.

(3) It is possible to burn with equally high efficiency the poorer grades of coal which cannot be burned efficiently and in some cases not at all, on hand fired grates or on stokers.

(4) Smokeless combustion.

(5) Ash free from combustible and a considerably less quantity of ash than results from other methods of burning coal.

(6) Extreme flexibility to meet changes in load conditions.

(7) Increased stack capacity for a given size stack on account of much less air being used per pound of coal burned.

(8) All firing equipment outside of the furnace so that in case of emergency or breakdowns the equipment is immediately accessible.

(9) Fires can be immediately extinguished in case of tube ruptures or other difficulty with the boiler.

(10) No banking losses.

(11) Cleanliness of operation.

(12) Greater independence insofar as fuel supply is concerned on account of the wide range of coals that can be utilized.

Thrust Bearing on Turbine Changed

Clearance at Top Should Exceed That at Bottom Since Vacuum Causes Sagging of Cylinder. By R. H. Morris

CONSIDERABLY OVER a year ago our two small turbines (1500 and 2000 kw.) developed an excessive end thrust, toward the dummy end of the spindle, resulting in several more or less serious accidents and considerable reblading. After experts had thoroughly examined the machines, boilers, piping, oil and available past records, the major portion of the trouble was attributed to excessive radial clearance augmented by the sag of the cylinder.

Due to the downward vacuum pull over a period of years, the cylinder sagged sufficiently, between the two bearings, to allow the blades to rub. The engineer in charge at that time assumed the rub to be due to lack of clearance and accordingly turned the blading down to what he considered the proper diameter. Evidently this was repeated the second time, for in at least one machine the clearance amounts to almost three times the proper value. During this period the dummy remained unchanged, the end thrust increasing with each decrease in blade diameter and throwing an additional load on the thrust bearing. The spindle running at high speed continued to run true while the sag of the cylinder pulled the axis of the bearing block out of line with the shaft, throwing most of the thrust on the rings of the lower half of the bearing.

All the trouble happened before the writer took charge and undoubtedly other difficulties were involved of which there is no record. These, however, were accepted as the most important and it was decided to eliminate the trouble either by new blading or by increasing the thrust bearing area. The latter was decided to be the more practical because of the lower cost, shorter time required and uncertainty regarding the exact nature of the trouble, which after all might not be corrected by new blading. Three rows of blading had to be replaced and plans were made to change the thrust bearing at the same time.

As shown in Fig. 1, the old bearing was of the marine type. The thrust sleeve fits the spindle snugly and is held in place by the spindle nut. Renewable rings are fitted to the thrust bearing block, the entire bearing occupying the space outlined by dimensions B and C in Fig. 2, which shows a cross section of the bearing bracket. The lower half of the bracket is cast integral with the casing or cylinder. The cover, however, is separate from the cylinder and as this is also true of the number two bearing cover, the spindle may be held in the casing in alinement without replacing the upper casing half. Lateral adjustment of the spindle is effected by means of an adjusting screw held in the trip gear case. To change the clearance the block is moved backward or forward in the bearing, drawing the entire spindle with it. This bearing was replaced by one of the Kingsbury type, of a standard size, which is both longer and of larger diameter than the old one. The outline of the thrust block is shown by the dotted line in Fig. 1. The greater length made little difference but the change in diameter meant boring out the bearing bracket almost a quarter of an inch.

In Fig. 3 is shown the boring bar which was made and kept until the arrival of the erector who was to do the rebuilding. This boring bar consists of a sleeve E threaded

the entire length, bored with a slight taper fit and taking the place of the thrust sleeve on the shaft. The sleeve F threaded 4 or 5 in. on the inside, is provided with a tool holder and made long enough to project beyond the bearing bracket. The bearing covers are tightened, the spin-

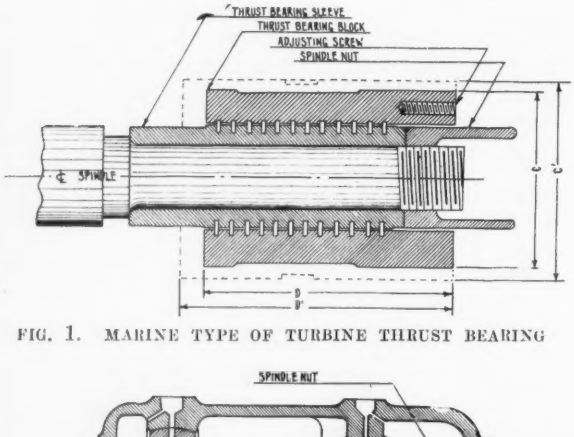


FIG. 1. MARINE TYPE OF TURBINE THRUST BEARING

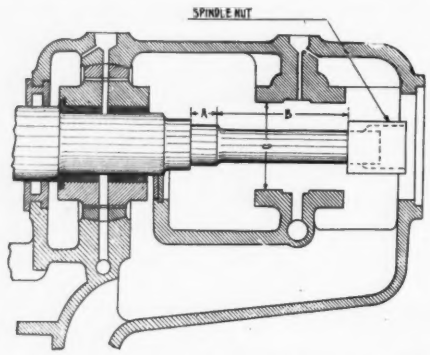


FIG. 2. CROSS SECTION OF TURBINE THRUST BEARING BRACKET

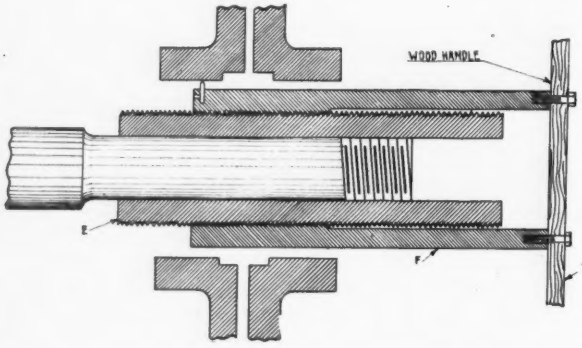


FIG. 3. HOME-MADE BORING BAR FOR ENLARGING BEARING BRACKET BY HAND

dle with sleeve E is held stationary while F, holding the tool, is turned by two men, one on each end of a wooden handle.

No work could be done on the bearing while the spindle was being rebladed and after the erector finished this he found it necessary to take almost 1/64 in. off the shroud rings of the new blading. That night the erector, a machinist and the writer made the apparatus shown in Figs. 4 and 5, to bore the bearing and turn the blading at the same time.

In Fig. 4 the sleeve H with a slight taper fit is driven on the shaft, the tool held in holder J travels in a slot, the feed being controlled by the feedscrew K. The entire apparatus turns with the spindle.

In Fig. 5 the file is held in position by the holder M, the pressure or feed being regulated by the setscrew N. The spindle is rotated, lateral movement or end thrust is taken care of by forcing the spindle toward the generator end, until tight against the dummy rings, and holding it in place by means of a roller, bearing on the outside of the dummy. The roller is not shown in the illustrations but is held in place the same as the holder M.

Turning the spindle proved to be the most difficult. The driver must be considerably above the center line of the turbine so that the belt will clear the casing, and trouble was experienced in finding a good belt surface. A 10-hp., variable speed, d.c. motor running at its lowest speed was finally belted to a well taped spindle ring and gave excellent results, although the resistance box used became so hot that the motor had to be stopped occasionally.

In the course of checking clearances, the erector found that the bottom clearance greatly exceeded that of the top. He stated that this is a condition frequently found, due to the general impression that wear on the bearing will lower the spindle and decrease the bottom clearance. As a matter of fact, single exhaust turbines will almost invariably start to rub at the top because of the cylinder sag caused by the vacuum. This takes place more rapidly than the wear and gives the effect of the spindle actually rising. If anything, he recommended making the top clearance greater than the bottom.

Unfortunately it is too early to give actual data as to the life or action of the new bearing beyond the fact

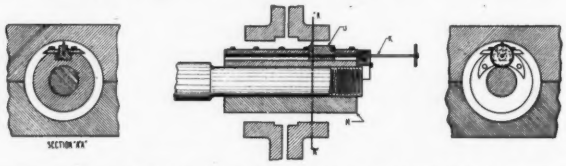


FIG. 4. BORING BAR, WITH HAND CONTROLLED FEED SCREW, TURNS WITH SPINDLE

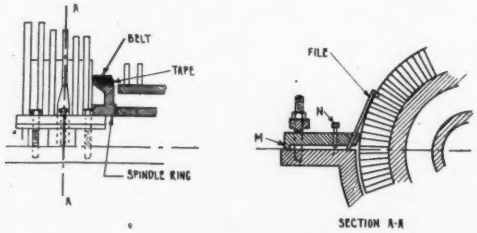


FIG. 5. TAPE ON SPINDLE RING USED AS PULLEY FOR DRIVE BELT AND FILE CLAMPED ON PERIPHERY OF BLADING USED FOR OBTAINING CLEARANCE

that it is so far proving satisfactory, runs considerably cooler than the old one and has relieved the minds of the operators, as they had formerly been expecting to hear or see a wreck any minute. This is the first time a turbine, built by this manufacturer, has had a bearing change of this kind, but since results have been so pleasing, we plan to change the bearing on the second machine in a short time. As no blading is to be replaced on this, we plan to use the hand boring bar shown in Fig. 3, because of its simplicity and ease of setting up. This will also give us a good idea of the relative merit of the two boring bars.

Useful Uniflow Engine Calculations

Methods of Calculating Clearance and Relation of M.E.P. to Cutoff and Steam Consumption. By Fred William Bosch

IN THE DESIGN of uniflow engines, important problems arise in the determination of the clearance and the relation of m.e.p. to steam consumption and cutoff. This article presents some useful methods of finding these, which may be applied to the analysis of engine performance, using the Mollier diagram and indicator diagrams from the engine.

Let us first discuss the method of determining the clearance. For an engine with compression of 90 per cent of the stroke (which will be assumed throughout these calculations).

$$S_o = \frac{90 \times V_1}{V_2 - V_1}$$

In this formula S_o = per cent clearance, theoretical; V_1 = specific volume of steam at throttle pressure; V_2 = specific volume of steam at exhaust pressure multiplied by the per cent of dryness when expanding adiabatically from throttle to exhaust pressure.

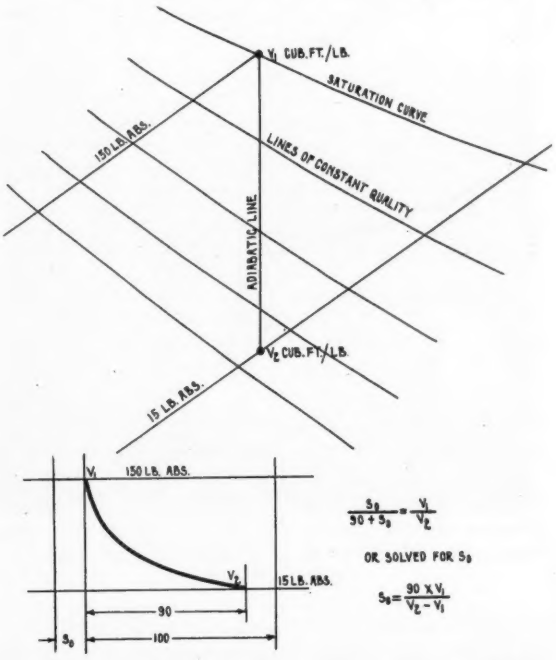


FIG. 1. UPPER DIAGRAM IS A PORTION OF THE MOLLIER DIAGRAM, SHOWING METHOD OF FINDING X. LOWER DIAGRAM SHOWS 90 PER CENT COMPRESSION LINE

In this connection the Mollier diagram will be found useful and convenient. In the lower section of Fig. 1 is shown a pressure-volume diagram illustrating the working out of the above formula as applied to a 90 per cent compression curve. In the upper section, a portion of the Mollier diagram is shown; V_1 can be taken from the steam tables. Specific volume V_2 equals X V_s, where X is the quality and V_s the specific volume of dry saturated steam at that pressure.

The upper part of Fig. 1 shows the method of finding X from the Mollier diagram. From the point on the saturation curve where the throttle pressure line intersects it, the adiabatic expansion line drops until it intersects the exhaust pressure line, when the quality X may be read. After finding V_1 and V_2, their values are inserted in the above formula to give the theoretical clearance.

In the actual uniflow engine, the per cent of dryness at the beginning of compression is a little greater than that given by the above method. In addition to this, the compression line is steeper than the adiabatic because of valve leakage and heat added by the cylinder walls to the steam under compression. It will be seen, therefore, that the actual clearance volume will exceed the theoretical; in practice, the actual clearance of uniflow engines should be 1¼ times the theoretical for saturated steam and 1 1/5 times the theoretical for superheated steam, since the latter is not such a good heat conductor as saturated steam. For condensing engines the theoretical clearance required is less than can be actually obtained in the design of the cylinder.

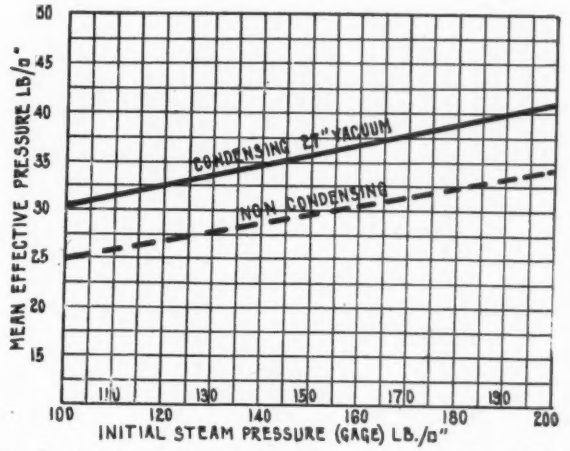


FIG. 2. ACTUAL CLEARANCE VOLUMES FOR VARIOUS INITIAL PRESSURES ARE GREATER THAN THEORETICAL

Figure 2 shows actual clearance volumes for 90 per cent compression and both saturated and superheated steam conditions. Comparing the actual values given on Fig. 2 with theoretical values, we find, for instance, that with saturated steam at 170 lb. abs., the clearance volume (using X from the Mollier diagram and working it out with the above formula) is 12.1 per cent. From Fig. 2, however, we get 14.3 per cent for the same initial pressure.

Another method of arriving at the necessary clearance volume is to assume a coefficient k for the compression line and to use the formula pv^k = constant. From indicator cards taken from non-condensing engines, the value of k is found to be between 1.153 and 1.25. Coefficients as high as 1.3 on non-condensing engines, with either saturated or superheated steam (100 deg. F. superheated) indicate leaky valves.

In the accompanying table is shown the method of calculating the relation of m.e.p. to cutoff and steam consumption. These calculations are made for an engine

TABLE SHOWING RELATION OF M.E.P. TO CUTOFF AND STEAM CONSUMPTION

100 feet Stroke - Piston Area, 144 sq. in. - Spec. Volume, 3.88 at 100 lb. gage or 115 lb. Absolute Steam Pressure at throttle; Non-condensing; Clearance, 18.05 per cent theoretical.

A	B	C	D	E	F	G	H	I	J
Release # abs.	% Dryness Release	# Steam at Release	# Steam per 100 cu. ft. displacement.	Cut-Off %	B.T.U. per # to release	(C)x(F) B.T.U.	B.T.U. per 100 cu. ft. displacement.	M.E.P.	Steam per I.H.P. #
15	88.5	4.65	--	--	149	693	--	--	--
17	89.1	5.69	1.04	4.03	141	802	152.7	8.25	17.36
21	90.0	6.85	2.20	8.53	128	876	314.0	16.94	17.87
24	90.7	7.71	3.06	11.88	117	902	405.5	21.86	19.27
27	91.3	8.53	3.88	15.07	110	938	507.0	27.38	19.56
30	91.8	9.36	4.71	18.28	102	954	589.	31.78	20.40
35	92.6	10.73	6.08	23.60	91	976	722	38.95	21.48
40	93.3	12.11	7.46	28.90	82	994	847	45.70	22.45
45	94.3	13.38	8.73	33.85	73	977	939	50.68	23.65
50	94.6	14.68	10.03	38.90	65.5	963	985	53.15	25.90

Spec. Volume; 3.88 at 100 lb. Gage or 115 lb. Absolute Pressure; Condensing, 2 lb. Back Pressure; Clearance, 2.55 per cent theoretical.

2	81.2	.658	--	--	266	174.9	--	--	--
4	83.3	1.362	.704	2.73	229	312	175	9.45	10.23
7	85.3	2.242	1.584	6.16	197	441.5	369	19.92	10.93
11	87.2	3.350	2.692	10.45	170	569.5	565.5	30.52	12.15
16	89.5	4.41	3.752	14.55	149	657	729	39.35	13.11
19	89.5	5.485	4.768	18.48	133	722	870	46.96	13.98
24	90.7	6.67	6.012	23.25	117	780	1023	55.28	14.96
30	91.80	8.14	7.482	29.03	102	830	1177	63.50	16.40
35	92.6	9.33	8.672	33.65	91	849	1302	70.3	16.98
40	93.3	10.44	9.782	37.95	82	857	1405	75.8	17.73
45	94	11.60	10.942	42.45	73	847	1480	79.9	18.80
50	94.6	12.72	12.062	46.8	65.5	833	1570	84.8	19.43

with piston area of 144 sq. in. stroke of 100 ft. and initial pressure of 100 lb. gage, both condensing and non-condensing. The writer has worked out many other tables on this basis for other conditions of pressure and superheat, but repetition of them would be superfluous, as the method given here can be followed for any conditions. It may be of interest, in this connection, to refer to Fig. 3, which shows the most economical m.e.p. for uniflow engines, using initial steam pressures from 100 lb. to 200 lb. gage, operating non-condensing or against a 27-in. vacuum.

In obtaining the values shown in the table, the theoretical clearance, S_0, is calculated from the first formula given above. Then assume release pressure in column A. The per cent of dryness in column B is found on the Mollier diagram, as explained above, assuming adiabatic expansion.

Weight of steam at release (column C) is found by multiplying the "specific weight" of steam at release pressure by the volume at release pressure and dividing by

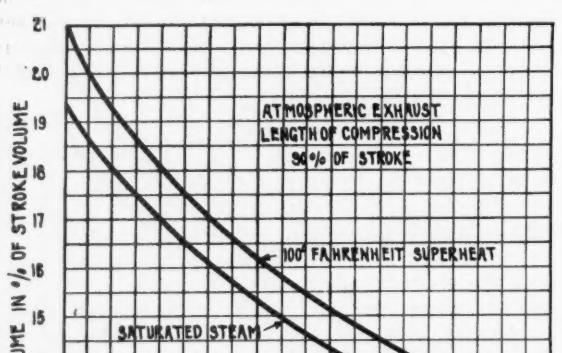


FIG. 3. CURVES SHOWING MOST ECONOMICAL M.E.P. FOR UNIFLOW ENGINES UNDER VARIOUS CONDITIONS

the per cent of dryness. Assuming a 100-ft. stroke cylinder, with a piston area of 1 sq. ft., the volume at release for 15 lb. release pressure would be $(100 + 18.05) - 10 = 108.05$ cu. ft. The volume at 1.7 lb. release pressure and above is $100 + 18.05 = 118.05$ cu. ft. The weight of steam used per 100 cu. ft. displacement (column D) equals weight of steam at release pressure minus weight of steam at 15 lb. release pressure.

Cutoff in per cent (column E) equals (column D) divided by specific weight of steam at throttle pressure.

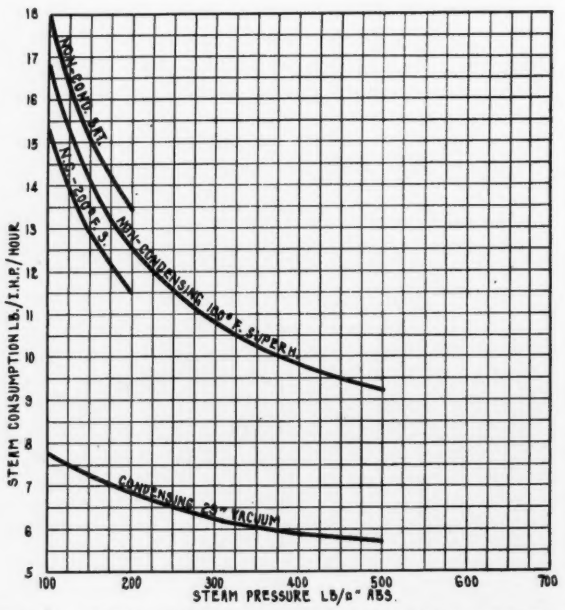


FIG. 4. CURVES SHOWING ECONOMY OF HIGH PRESSURE STEAM, USING RANKINE CYCLE

The B.t.u. per lb. to release (column F) are found on the Mollier diagram assuming adiabatic expansion.

Work done in B.t.u. per 100 cu. ft. displacement (column H) equals B.t.u. (column G) opposite the release pressure assumed, minus the B.t.u. (column G) opposite release pressure of 15 lb. or exhaust pressure, plus

$$\frac{118.05 \times Y \times 144}{778}$$

where Y equals release pressure minus exhaust pressure.

$$\text{m.e.p.} = (\text{column H}) \times \frac{778}{100 \times 144}$$

Steam consumption per i.hp. (column J) equals

$$\frac{33{,}000 \times 60 \times (\text{column D})}{144 \times 100 \times (\text{column I})}$$

An idea of the economy of high pressure steam is presented by the curves in Fig. 4, representing the Rankine cycle with complete expansion, for various steam conditions.

ALL NEWLY CONSTRUCTED steam lines should be thoroughly blown out with steam before the last joint is finally made up. It is not sufficient to blow them out with air alone, as many times there are present pieces of scale or other foreign matter that will not be removed by the air but will be loosened by the steam.

Oil Engines in the Pumping Field

British Practise Shows Best Economy with Airless Injection and Semi-Diesel Types. By F. Johnstone-Taylor

DEVELOPMENT of the oil engine and its combination with various classes of pumps is proceeding apace in Britain. Engineers concerned with pumping schemes, especially those under about 400 hp., have long been aware of the relative inefficiency of steam plants which now figure only in the shape of large triple expansion water works engines, although the recent installation of uniflow engines is an interesting departure from orthodox practice. All over the British Empire there are a number of pumping plants driven by gas engine suction—producer combinations, a type of power unit little known in America, but with the perfection of the oil engine these are now rarely installed. Nevertheless they have functioned quite satisfactorily.

Variety of Types Used for Pumping

British oil engine practice is rather different from American. Diesel engines with air blast injection are

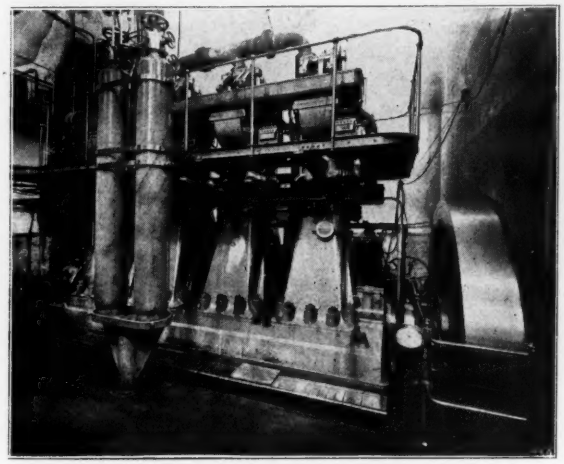


FIG. 1. FOUR-CYLINDER DIESEL FOR PUMPING AT HAMPTON, ENGLAND

mainly four-cycle engines invariably vertical and are generally regarded as best suited for units of 400 to 1000 hp. Large Diesels outside of the marine type are not built here. The cold-starting airless-injection engine is now regarded as the most favorable proposition for the above mentioned size of units, while the semi-Diesel engine is also taking its place in the pumping field. Diesel engines as built in Britain average 50 to 100 hp. per cylinder and are generally four-cylinder units of the type installed at the Hampton (London) pumping station shown in Fig. 1. They are designed for a speed of about 150 r.p.m. and are generally open type engines. Otherwise their construction calls for no special comment.

The type of cold-starting engine being built by gas engine manufacturers naturally follows orthodox gas engine practice as a single cylinder engine of 50 to 125 hp. or as a twin engine for larger units. Vertical engines of 500 hp. are sometimes built as four-cylinder engines but are used mainly for electric power generation. A typical horizontal airless-injection engine of the twin-cylinder type may be seen at the Cheddar (Bristol) waterworks pumping station shown in Fig. 2.

The airless-injection engine is now much preferred to the Diesel with its attendant air blast, especially as the former can show a fuel economy comparable to the latter in the sizes used for pumping. Moreover they run satis-

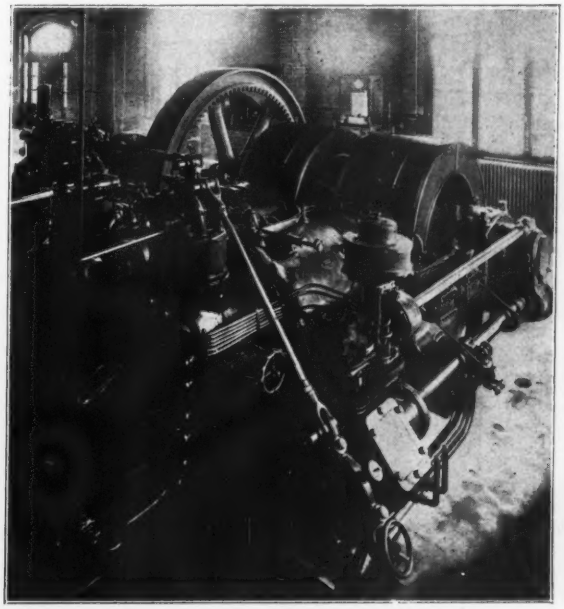


FIG. 2. AIRLESS-INJECTION, TWIN-CYLINDER ENGINE DRIVES CENTRIFUGAL PUMPS AT THE BRISTOL WATER WORKS

factorily on Diesel oils and although the compression pressure varies with the design some engines show excellent results when this does not exceed 300 lb. per sq. in. They are, however, still referred to as high-compression oil engines.

The semi-Diesel engine is so well known that comment here is unnecessary beyond stating that the British engines are built on the unit principle, averaging 25 to 50 hp. per cylinder and are generally constructed as two or four-cylinder vertical engines. There is a tendency for builders to put forward a superior type of semi-Diesel engine in the shape of eliminating the crankcase induction and either providing a separate air pump or utilizing the lower part of the cylinder as a pump and constructing the engine with a crosshead. A somewhat higher compression is then used and the wastage of oil attendant upon crankcase compression is eliminated.

Representative Diesel Pumping Plants

It is now almost 20 yr. since the Manchester Canal Co. took what was then a bold step in installing several Diesel-driven centrifugal pumping units for handling the water used in the canal locks during dry weather. As shown by Fig. 3, in the side elevation of one of these plants the engines are of the four-cylinder, vertical type, direct coupled to the pumps which have an average lift of 17 ft. Under test at the time of installation they

showed a fuel consumption of 0.473 lb. per b. hp-hr. when developing 150 hp. and 0.780 lb. per pump hp-hr., a performance regarded as quite remarkable at the time and which is considered quite good even today. The oil engine thus became established here as a suitable means of pump operation and several plants have been installed.

The Diesel engine, however, is now regarded as best suited to units of 400 to 1000 hp. and two successful Colonial installations are seen at Gezira, Sudan and Kom-Ombo, Egypt. The three units at the former are 1000 hp., four-cylinder, four-cycle Diesels constructed on the Bur-

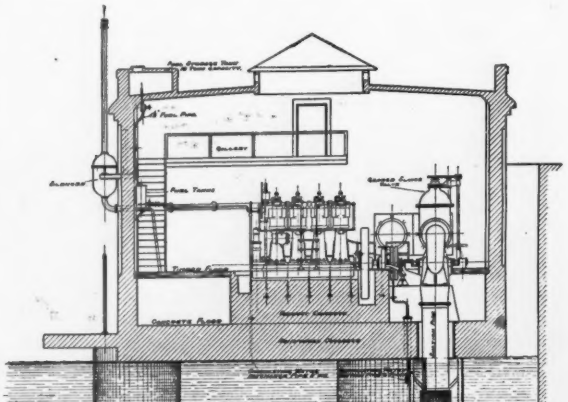


FIG. 3. SIDE ELEVATION OF CANAL PUMPING STATION WITH FOUR-CYLINDER VERTICAL DIESEL ENGINES

meister and Wain system and have oil cooled pistons although otherwise not calling for any special description. The latter plant is notable for its 2000 hp. Sulzer two-cycle engine. Its exceptionally good performance under test is shown by the fuel consumption of 0.53 lb. per pump hp-hr. This was actually less than the guaranteed consumption of 0.595 lb. per b. hp-hr.

Prior to the perfection of the airless injection engine, small Diesels figured largely in the operation of small water works plants of under 100 hp., although mention should be made of a plant at Rugby involving a 200-hp. engine driving a high lift centrifugal pump. This was installed in 1911 and a recent duplication there was one of the first to be equipped with gear reduction between engine and pump. With a duty of 100,000 gal. per hr. to a head of 230 ft., these engines show a fuel consumption of 0.55 lb. per pump hp-hr.

At Hampton, the plant belonging to the Metropolitan Water Board, a concern which controls the whole of London's water supply, is another example of the use of gearing to insure both pumps and engines running at the most economical speed. These engines develop 400 hp. at 175 r.p.m. and drive the pumps at 1100 r.p.m. The latter have a duty of 4½ million gal. per 24 hr. against a head of 300 ft. and under test showed an average fuel consumption of 0.525 lb. per pump hp-hr.

Apart from a fair number of ram pump installations, of which several are operated in London, those at the Alexandria, Egypt, water works are worthy of mention in view of their having been run in parallel with existing steam units of similar capacity. The engineer's report of their performance aroused a good deal of interest because during a year's operation, a comparison of costs showed about $32 per million foot tons for the steam units against approximately $15 for the Diesels. The annual saving effected at this station by the use of the Diesels is stated to be approximately $25,000, in spite of the fact that the steam plant, while not ultra modern, is up to the average.

An interesting development in pumping practice is the use of oil engines combined with centrifugal borehole pumps. The engines themselves call for no comment beyond stating that placed just beside the well head they drive the pump shaft through a gear box at the well head as shown by the Sulzer installation in Fig. 4. This method of raising water from relatively deep boreholes is of interest, since the arrangement involves a specially designed five-stage pump as installed at the Somerford station of the South Staffordshire Water works. The pump is in axial alinement with the delivery pipe from which it is suspended and inside this delivery pipe is the shaft with its necessary steady bearings. In a condition of rest the shaft is entirely in tension; during running this tension

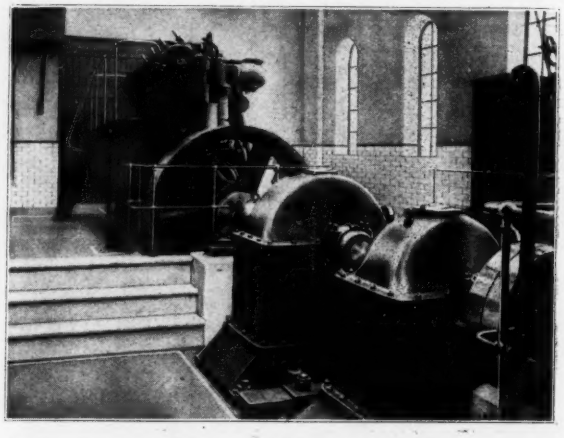


FIG. 4. ARRANGEMENT OF DIESEL ENGINE AND GEARING FOR DRIVING DEEP-WELL CENTRIFUGAL PUMPS

may be taken up either by a thrust bearing, hydraulic balance in the pump, or both. Steady running is assured by the provision of bearings which usually take the form of lignum bushes set in housing gripped by the flanged sections of the trunk tube. No lubrication is required and the mechanical construction permits accurate alinement. This method of well pumping, as may be inferred, is well adapted to electric drive by a vertical shaft motor, but an oil engine drive through gearing has proved remarkably successful. The Somerford installation, to which reference has previously been made, consists of a 300-b. hp. engine, a six-stage centrifugal well pump and a five-stage centrifugal surface pump, both driven by the one engine and having a duty of 700 g.p.m. to a total head of 822 ft. Under test this plant showed a fuel consumption of 0.649 lb. per pump hp-hr. and a pumping cost of 65 cents per 1000 gal., raised 100 ft. Such a plant is of course relatively costly and a similar installation involving semi-Diesel engines is now being installed at Gainsborough.

Many of the plants now driven by this type of engine are quite small and are practically identical with the usual type of small gas engine driven plant. As already shown in Fig. 2, the installation at the Cheddar station of the

Bristol Water works may be of interest as relatively large twin engines are installed and have five-stage centrifugal pumps driven through gearing. These engines develop 235 b. hp. at 175 r.p.m. and the pumps, driven at 1000 r.p.m., have a capacity of 1400 g.p.m. against a head of 300 ft. The engines showed the extremely low fuel consumption of 0.414 lb. per b. hp-hr. and a similar plant at York with 160 b. hp. twin engines, 0.43 lb. per b. hp-hr., showing that this type of engine is really a better proposition than the Diesel and is less costly to build. In the pumping field, its extended use in the near future is foreshadowed.

Until recently the semi-Diesel engine has not been adopted for pumping except in the case of small privately owned plants. When combined with a direct driven centrifugal pump it provides an extremely simple and inexpensive installation. For intermittent work it is ideal and this is borne out by its adoption for replacing out-of-date steam plants on the English marsh lands where pumping has to be resorted to at certain seasons of the year. These plants have to be attended to by unskilled men and as the cost of these installations and their upkeep has to be borne by the local landowners, first cost has to be kept down to the absolute minimum. The latest installation, consisting of two 180 b. hp. four-cylinder units driving centrifugal pumps with a capacity of 4000 cu. ft. per min. to a head of 17 ft. is of more than usual interest since it shows more favorable performance than some existing Diesel units. The engines have a speed of 300 r.p.m. and represent standard semi-Diesel engine practice in Britain.

The Deadly "Short-Cut"

SO OFTEN are we tempted to take the easier path in the doing of our work—sometimes with detrimental results.

On August 5, on the Monroe-Dundee tie line, of the Detroit Edison system, George Murrin—whose good record was commented upon most highly by his superiors just the day before this story starts—was engaged in the installation of a second cross-arm in a double-arm construction and was using an open end (alligator) wrench, 12 in. long, to tighten the bolt which goes through the "spacer" block between the arm, when he raised his wrench to "get another bite" and inadvertently struck the outside wire of the 24,000-v. flat construction on the top arm.

He had extended his left leg to the pin of the 2300-v. line running on the arm five feet below the upper arm, when his wrench, making contact on 24,000-v. line, caused his foot to slip into the 2300-v. wire, allowing current to pass through and ground his body, and causing his clothes to be burned in the resultant flash, which involved his entire body. He dropped limp in his belt and his head rested on the foot of his fellow-worker on the pole, Robert McEwan, who had also received a shock through the contact which he had while holding with a pair of pliers the head of the bolt on which Murrin was tightening the nut. Both men were unconscious for a brief period, when McEwan revived sufficiently to release his leg from under Murrin's head and raise it over the top of the cross-arm on which he had been hanging and descended to the ground. He ascended the pole again, taking up a hand-line, which he placed over the cross-arm and tied one end in the D-ring of Murrin's belt and then releasing the body by unsnapping the "safety belt" from around the pole, helped the driver of the truck and other men who came to the scene of the accident to lower Murrin to the ground where the blaze smouldering in Murrin's clothes was immediately extinguished and the arrival of the hospital ambulance awaited. There was no need to apply artificial respiration because Murrin voluntarily resumed consciousness and in full realization of what had happened to him and his fellow-worker began to speak rationally of the occurrence.

Within 10 min. after the flash, the district inspector came to the scene of the accident and taking Murrin in his automobile, rushed to the hospital at Monroe, Mich.

First aid was promptly applied to the injured man. McEwan, by the way, suffered no burns or further evidence of shock although he had been in a precarious position on the pole when Murrin induced the flash. The prompt operation of the automatic switch at Monroe shut off the current which probably would have burned both bodies to a crisp in a brief interval. Murrin remained rational until nearly midnight. At 2:00 a. m., however, he died as a result of the extensive burns which he had received.

Now we say, as often we hear said: "He was a very careful man." Indeed he had been. He entered Detroit Edison service on July 11, 1917, serving as a lineman until April 17, 1918, when he entered military service. He returned on July 10, 1919, carrying on in the same capacity until February 1, 1923, when he left to go West.

He again entered the service of the Company on July 16, 1923, and became interested in the "Hot Stick Gang" work for which he qualified and succeeded by his own enthusiastic interest and extreme caution to merit the position of foreman of the Hot Stick Crew in the Ann Arbor District. He was always much interested in his work and was known as an "extra-cautious" workman. But in this case he thought that he saw a chance to make a short-cut. He figured that he could save about one minute and a half by attempting to screw up the bolt without taking the precaution of cutting the tie wire on the 24,000-v. line and raising the conductor with his jew clamp to an easily secured clearance of several feet and thereby accomplish the completion of his job in perfect safety.

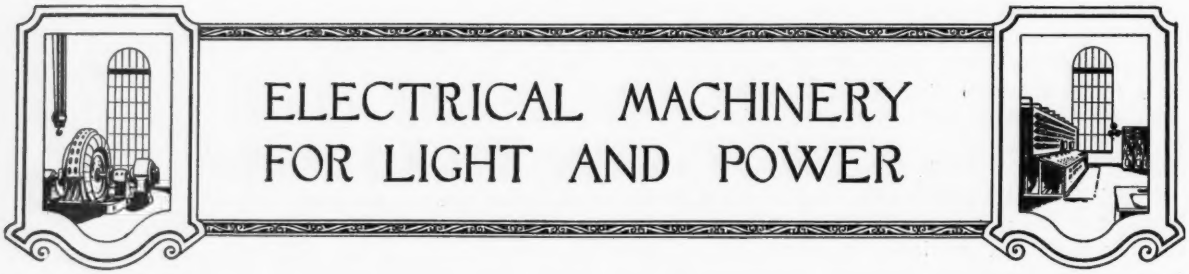
And as a result of his desire to make the short-cut—even in the face of a suggestion by his fellow-worker—he exposed his life to an unnecessary hazard and endangered others as well by his needless hurry.

No: It does not pay to take a chance needlessly!—The Detroit Edison "Synchroscope."

Ash Disposal Methods Demand Attention

IN THE ARTICLE under the above title that appeared in our September 1 issue, the percentage of copper in the copper-steel alloy mentioned on page 887 in the tests made by the Pittsburgh Testing Laboratories Co., was incorrect. The copper-steel alloy in question contained 0.26 to 0.28 per cent copper, instead of 26 to 28 per cent, as stated.

CONSIDERABLE SUCCESS has attended the practice of covering the bottoms of newly constructed fuel oil steel storage tanks with a 4-in. layer of asphalt over which is placed a 4-in. layer of sand. This also applies to steel water storage tanks. The steel bottom of the tank should first be thoroughly dried, cleaned and painted with red lead.



Relay Protection of Transmission Lines

PROTECTIVE RELAYS PLAY AN IMPORTANT ROLE IN GUARDING POWER SYSTEMS AGAINST SHUTDOWN. BY C. A. ANDERSON*

RAPID GROWTH in electrical power systems in recent years has necessitated a parallel advance and improvement in protective relays and relay schemes. Two main factors, namely the increase in the size and complexity of systems and the necessity for service without interruptions, have brought forward the demand for more efficient and complete relay protection of transmission systems.

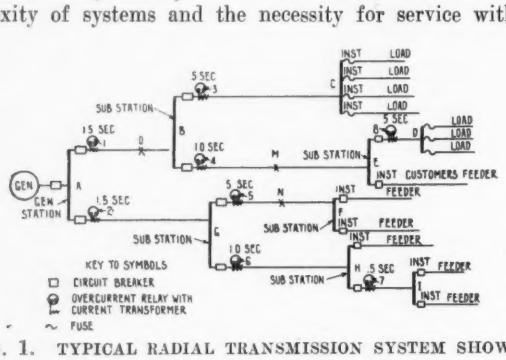


FIG. 1. TYPICAL RADIAL TRANSMISSION SYSTEM SHOWING RELAY PROTECTION WITH OVERCURRENT RELAYS

Trend of present day practice in the transmission of electrical power is towards larger and more complicated systems of interconnected lines rather than a greater number of smaller isolated systems. As a natural consequence, the protective relays and relay schemes as used a few years ago for disconnecting lines upon the occurrence of short circuits or other faults have become inefficient and new designs and schemes of connections have been made. The interconnection of the present system as called for in the formation of the super power development will no doubt require still further refinements and improvements in relay practice.

With the introduction of electrical power into industry where it now furnishes the driving force for machines and processes of all descriptions which must be run continuously, continuity of service has become a big factor in the production and transmission of electricity. Modern transmission systems of any size are usually so arranged that substations supplying customers who demand continuous service have more than one source for drawing power from the generating stations. This has made necessary the incorporation of discriminating features in protective relay design so that with the proper application of protective schemes to transmission systems, only the faulty section of line will be disconnected upon the occurrence of trouble and that this will be accomplished so quickly that little disturbance will be noticeable on the remainder of the system and no service will be interrupted.

*Formerly with the Westinghouse Electric & Mfg. Co., now Prof. of Electrical Engineering, University of Pittsburgh.

OVERCURRENT RELAYS

Simple radial schemes of transmission as used in small power systems can be amply protected from faulty line conditions by the application of overcurrent relays. The relay problem on such systems is to disconnect a faulty line from the generating source as quickly as possible and at a point between the fault and the generating station which is as near as possible to the fault, thus disconnecting the least possible amount of service. Continuity of service cannot be guaranteed on such systems, as the occurrence of a fault will necessarily discontinue service on that line to all customers connected towards the extremity of the line from the fault.

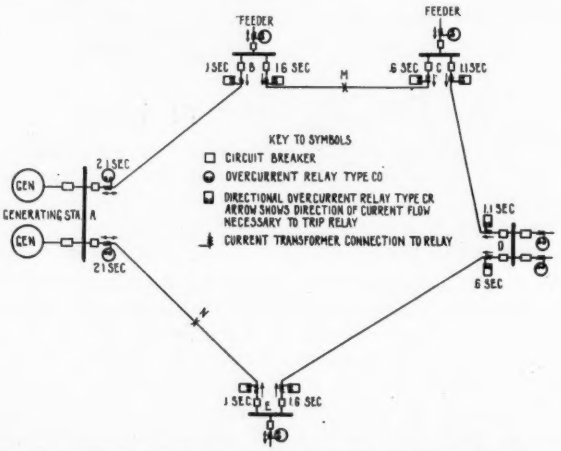


FIG. 2. TYPICAL RING OR LOOP SYSTEM WITH SCHEME OF PROTECTION MAKING USE OF THE OVERCURRENT AND DIRECTIONAL OVERCURRENT RELAYS

Overcurrent induction type relays of present design are highly accurate in their operation, both as to the amount of current required to operate and the time required for completion of the operation. Adjustments may be made to have the relay operate on various values of current and also to require various lengths of time to complete the tripping circuit after the operation has started. The inverse time characteristic of these relays is such that the greater the overload current flowing in the

relay windings, the shorter the time required to close the tripping circuit at any setting. The present induction type over current relays on the market have the distinct advantage over the older types of plunger relays in that all settings are accurate and dependable and the calibration is practically permanent when once made. Dependable settings may also be made by means of the calibrated scale and terminals whereas in the earlier relays every setting had to be tested before it could be depended upon.

Directional Overcurrent Relays on Loop Systems

Ring or loop transmission systems used by large operating companies present more complicated relay problems than radial systems. Such a system serves to give each substation on the loop two lines over which it can draw power from the generating stations and thus makes continuity of service to the consumer possible. The main problem in relaying such a system is to install relays at the generating station and on each side of each substation so that when trouble occurs on a line between substations, the relays at each end of that particular section will disconnect the faulty line without disconnecting service to any customers feeding off the loop. To make such a relay installation, straight overload relays may be used on the lines leaving the generating station. The relays applied on each side of the substation, however, require a directional element in addition to the overcurrent element. Thus directional overcurrent relays are used on

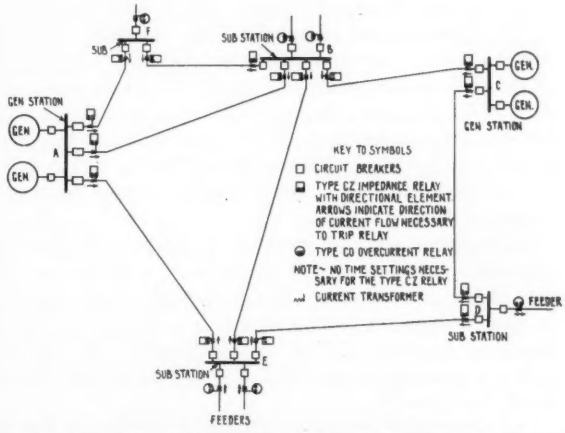

SUB STATION
GEN STATION
GEN
KEY TO SYMBOLS
CIRCUIT BREAKERS
TYPE CZ IMPEDANCE RELAY WITH DIRECTIONAL ELEMENT ARROWS INDICATE DIRECTION OF CURRENT FLOW NECESSARY TO TRIP RELAY
TYPE CO OVERCURRENT RELAY
NOTE- NO TIME SETTINGS NECESSARY FOR THE TYPE CZ RELAY
CURRENT TRANSFORMER
FEEDER
FEEDERS

FIG. 3. NETWORK TRANSMISSION SYSTEM SHOWING APPLICATION OF THE IMPEDANCE RELAY

each side of the substation, connected so that they will operate to close the tripping circuit only when the excess current flow is away from the substation bus bars. Relays on the same side of successive substations around the loop are given selective time settings, an interval of about 0.5 sec. being allowed between successive relays. Thus the relays between the fault and the nearest substation will always trip first insuring that only the faulty section will be disconnected.

Directional overcurrent relays of the latest design incorporate all the features of the overcurrent relay with the addition of a directional or wattmeter element. The directional element is extremely sensitive, being able to discriminate as to the direction of current flow with as low as one per cent of normal voltage existing. Both elements operate on the induction principle and the operation of both elements is necessary before the tripping circuit is completed through the relay.

Application of Pilot Wires

In loop systems which have more than four or five substations, certain difficulties are met in the application of directional and overcurrent relays. With a greater number of substations in the loop, in allowing a time interval between each successive relay, the time setting on the final relays becomes excessively high; 2.5 or 3 sec. is considered the highest settings which can be used with safety on systems of any size. One method used in overcoming this difficulty is the application of the pilot wire scheme of protection to the short sections of the loop and the other relays on the remainder. The pilot wire scheme furnishes protection whereby a fault in the protected section will cause it to be disconnected almost instantly, whereas faults in other parts of the system do not affect the relays of this section at all. The chief objection is the cost of the pilot wires, which have to be run from end to end of the section to be protected, but on short sections this is not serious.

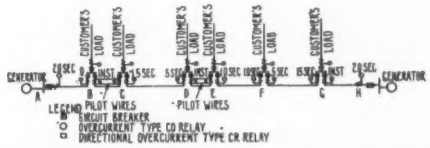


FIG. 4. INDUSTRIAL POWER LINE EQUIPPED WITH RELAY PROTECTION FOR SECTIONALIZING IN CASE OF TROUBLE

Network systems on loop systems with the tie lines connecting two substations in different parts of the loop may be protected with overcurrent and directional overcurrent relays, but an ideal application is hard to obtain on account of the time settings on the lines conflicting with those of the main line relays. It is often necessary in such applications to give the relays on the tie lines low time settings, so that when trouble occurs the tie lines will be cut out almost instantly, thus leaving a simple ring system with the desired selective time settings. In this way service is not interrupted to any of the substations and the tie lines can be connected in again as soon as the faulty section has been disconnected.

Impedance Relays

The impedance or distance relay manufactured by the Westinghouse Company has helped to solve many of the problems met with in applying protective relays to ring systems with a large number of substations on the loop or to network systems where it is difficult or impossible to secure an ideal application of time settings and proper sequence of operation for the relays on different parts of the system. This impedance relay is designed with a voltage restraining element so connected to the overload element moving parts, that the time of operation of the relay depends upon its nearness to the short circuit or faulty section of line. In other words, where the impedance relay is used for protection of a system no time settings are necessary, as the relays nearest on each side of the fault will operate and close their contacts before any of the other relays on the system. This relay is suitable for use both as a straight overcurrent relay and as a directional overcurrent relay, making it applicable in the

same way as the earlier designs of overcurrent and directional relays.

Several schemes of protection are in general use on parallel feeders. The principal difference between parallel feeder and other relay protection is that differential current schemes can be used on the parallel feeders, thereby making selective timing unnecessary. Either selective differential current relays or the directional overcurrent relays may be used for this protection. The time settings in such applications are usually almost instantaneous, thus clearing up parallel line trouble without interfering with selective time settings on the remainder of the systems.

Figure 4 shows a single transmission line connecting two generating stations some distance apart and serving several industrial customers' lines from substations located at various points along the line. With overload relays at the generators, only the machines are protected against excess current and a fault at any point throughout the entire length of line will cause the whole system to be disconnected. Figure 4 shows a simple relay application whereby a fault in any section of the line will cause only that part to be cut out and as long as both generators are running the service is not interrupted to any of the customers' lines. It will be noted that two sections are shown protected by the pilot wire scheme. Directional overcurrent relays are used on each end of the remaining sections except at the generators. The use of the pilot wire holds the maximum time down to 2.0 sec., whereas if the directional overcurrent relays were used throughout the maximum time settings at the generating stations would have to be 30 sec.

Electrical Apparatus Shows Steady Progress

RECENT REPORT OF THE N.E.L.A. ELECTRICAL APPARATUS COMMITTEE REVIEWS THE YEAR'S DEVELOPMENTS

PROGRESS IN all divisions of the electrical field is so rapid and new developments come with such frequency that it is often difficult to form an idea of what has actually been accomplished during a given period. The field is so large and its ramifications so diverse that it is not always a simple matter to recognize what is new and where the most notable advancement has been made.

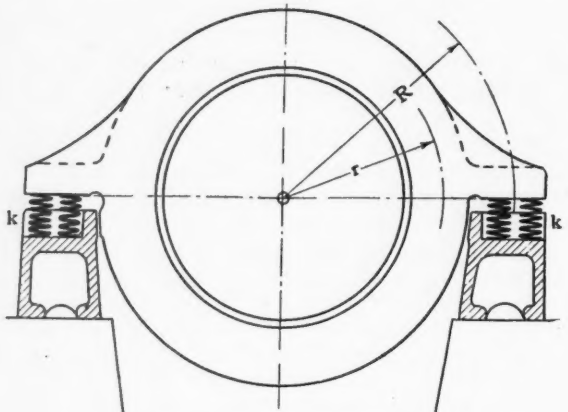


FIG. 1. SCHEMATIC ARRANGEMENT OF SPRING-MOUNTED STATOR

For those developments in the electrical industry more or less intimately related to the power plant field, perhaps the most comprehensive report published from year to year is that of the Electrical Apparatus Committee of the National Electric Light Association.

In the 1924-25 report of this committee which was presented at the recent convention at San Francisco, there is contained much that is of interest; while it is impossible in an abstract to cover any more than a few of the developments mentioned we are endeavoring here to present those which are of most importance to the power plant man.

Recent installations of large size generating units in several modern plants have led to intensive studies covering temperature measurements in the rotating fields in addition to those now being taken in the armatures and providing for closed ventilation schemes for dissipating more effectively the heat produced in such large generators. Two methods for measuring field temperatures are available; one by embedding a thermo-couple or resistance coil in the rotor and connecting it to auxiliary collector rings, and the other, by measuring the increase in resistance of the rotor winding by means of an instrument calibrated to indicate temperature.

The first method, employing an embedded detector, does not seem to be practical. The detectors are necessarily of delicate construction and would be unable to withstand the heavy pressures and vibrations incident to large rotors. (We understand, however, that an arrangement of this type has been used on the 50,000-kw. Parsons turbine recently installed at the Crawford Avenue Station in Chicago.—Ed. Note.)

Using the winding itself as a temperature detector gives an average value for the rotor as a whole and not that of the hottest part. This method, however, has been in use for several years and has been approved by the American Institute of Electrical Engineers. No auxiliary collector rings are necessary, although additional brushes would be desirable.

In the closed systems of generator ventilation the use of inert gas in place of air, which is most commonly used, is interesting. Results of tests indicate a considerable reduction in the temperatures of large units where inert gas is used. This subject has received much study and a number of different cooling mediums have been considered.

Nitrogen has approximately the same properties as air. Carbon dioxide, which has a specific heat less than that of air, nevertheless has a specific weight great enough to make the required volume of gas for a given cooling effect about three-quarters that of air. The power required for circulating carbon dioxide is about two-thirds that of air for the same cooling effect.

Hydrogen presents some interesting advantages if the explosion dangers can be eliminated. The important characteristics of hydrogen when compared with air as a cooling medium for large high speed electrical machines are:

Lower density.

Higher thermal conductivity.

Higher forced heat convection.

Practically no damage to insulation by corona.

Prevention of fire.

Comparative effects on temperature conditions in a machine, of hydrogen versus air, may be summarized as follows:

Practical absence of windage loss when hydrogen is used, results in less heat to be removed from the machine.

Temperature drop required to transmit a given amount of heat from the copper to the iron, through the insulation, will be materially lower in hydrogen. The temperature drop required to transmit the heat across the laminations will also be lower in hydrogen than in air.

When the gas reaches the coolers, less temperature difference will be required to remove the heat from the hydrogen than from air, and therefore the hydrogen will be lower in temperature when it returns to the generator.

The cumulative effect of all these factors is a considerably lower copper and insulation temperature. This advantage may be used to increase either the life or capacity of the machine according to which seems the most desirable. Tests of a hydrogen filled machine show that with the same temperature rise, 30 per cent greater load can be carried and the efficiency would be more than 1 per cent higher.

Fire Protection

From reports received for the last two years, it is evident that considerable progress has been made in the application of carbon dioxide in generator fire fighting. The Hartford Electric Light Co., which installed some of this equipment several years ago, is extending the use of CO_2 for such purposes as an insurance against the damage which may result from generator fires.

In Pittsburgh, the Mellon Institute has carried on extensive investigations regarding the proportion of CO_2 required to smother a fire comprising burning insulation. These results show that about 20 per cent CO_2 is sufficient to smother a fire.

Cost of CO_2 fire fighting equipment is not large in proportion to the value of the machine protected thereby and the cost of re-charging is low. Because of the favorable comparison of carbon dioxide to air as a circulating medium in closed systems and its fire extinguishing qualities in any application, carbon dioxide deserves careful consideration for the various purposes it can serve.

Use of Frequency Changers

During the past year several large frequency changers have been installed in generating stations for interconnecting and transferring power between generating systems operating at different frequencies. The Brooklyn Edison Co. has installed a 35,000-kw. converter of the usual synchronous type. The New York Edison Co. has a unit of the same capacity but of special design to provide an electro-magnetic tie as well as a mechanical tie between the systems. (We understand that the Commonwealth Edison Co. has also ordered several large frequency changers for use between their 25 and 60-cycle systems.—Ed. Note.)

During the past year several 50,000-kw., 1200-r.p.m., single-shaft turbo generators have been placed in operation and orders have been placed for units of the same type and capacity but for 1800 r.p.m.

Rapid growth of power systems and the increasing demands for reliability of service during the past five years have brought the substation problem into the foreground. Experience has shown that the design of a substation must be such as to withstand the strains of abnormal as well as normal voltages and currents.

Aside from the actual loading of transformers and other substation equipment, the oil circuit breaker situation presents at present the most acute problem. Possible values of short circuit current have increased rapidly with the increase in system capacity, so that, in many cases, breakers originally installed in substations are incapable of interrupting the maximum short circuit which might be imposed upon them under present conditions.

Much attention has been given to the best method of meeting this situation and relief has been obtained in many ways. In some cases, existing breakers were remodeled to obtain higher interrupting capacity. In other instances, complete replacements were made with larger

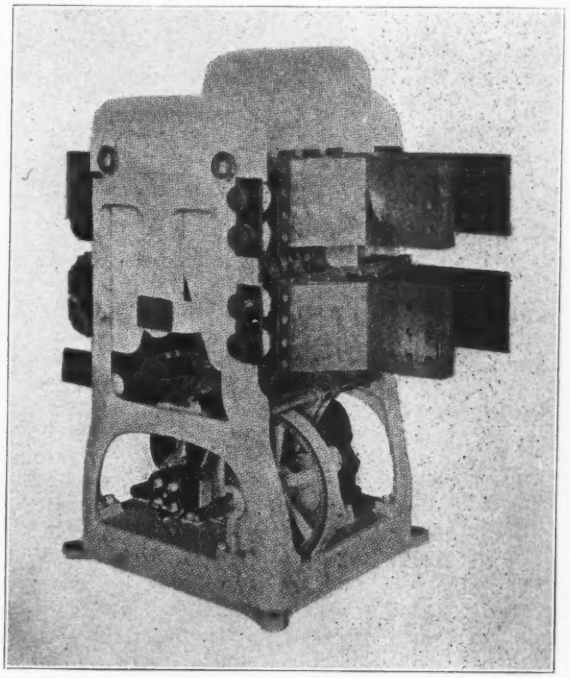


FIG. 2. D.P. TRIP-FREE QUICK OPENING AIR CIRCUIT BREAKER

breakers. Where space was available, reactors were installed in series with the existing breakers to limit the short circuit duty.

Progress in the development of the automatic a.c. substation has gone on at a rapid rate. Increasing interest is also being shown in the remote control or supervisory type of substations. New applications are constantly being found for the equipment developed primarily for these purposes, one of the most important of these being remote indication of meter readings of various kinds. The results of an inquiry by the subcommittee brought out the following uses for remote indication and control apparatus.

1. Control of operation of circuit breakers in a substation from another station or from the load dispatcher's office.

2. Remote indications of ammeter and voltmeter readings.

3. Remote indication of voltage readings on regulated distribution feeders; also indication of improper operation of voltage regulators.

4. Indications of drooping of any part of load on constant potential feeder supplying pole type series lighting transformers.

5. Continuous readings of totalizing wattmeters in generating stations.

6. Remote indication of switch positions in load dispatcher's office.

Distance over which indications are transmitted varies from 2 to 14 mi. In the systems in operation no serious

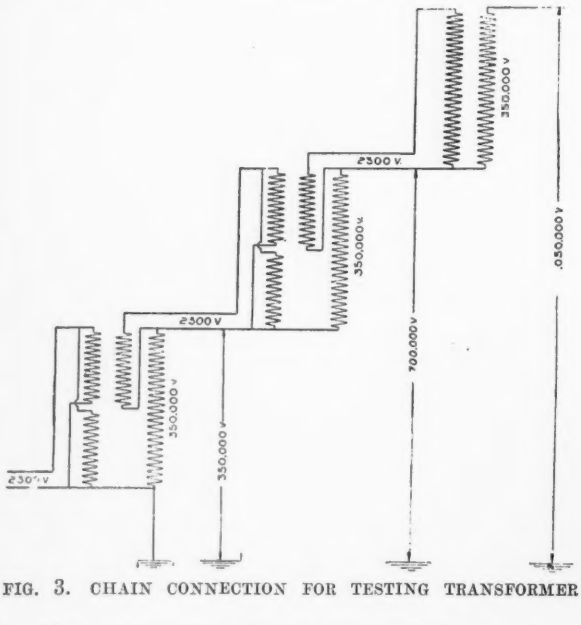


FIG. 3. CHAIN CONNECTION FOR TESTING TRANSFORMER

troubles were reported, although several faulty operations occurred due to transmitting and receiving distributors getting out of step.

In connection with methods of supervisory control, it is interesting to know that the application of carrier current is being considered. With this system, impulses of high frequency are substituted for the d.c. impulses ordinarily used. Experimental stations, which have been operated for several months, indicate that good results can be obtained from this type of control.

Among the most recent developments in a.c. substation apparatus is a fireproof insulator reactor of standard concrete construction having braided asbestos insulation. The insulation will prevent the possibility of failure on account of foreign material which might be drawn into contact with the conductors by the strong magnetic pull resulting when the reactor is subject to high values of current due to short circuit conditions. These reactors have been developed by the General Electric Co. The Westinghouse Co. has developed a vibration absorber for large single phase machines. This development is the result of past experience in which there had been serious damage to such machines due to the pulsating torque. The preventive used is a spring support for the entire stator and frame of the single phase unit. This method of support prevents the transmission of the stator vibrations to the supporting foundations and completely eliminates all vibration in the surrounding structure. This development has removed what was becoming a serious limitation to the size of single phase generators.

Although serious consideration has been given by many companies to the replacement of d.c. systems, whether in part or entirely, with some form of alternating current network, the conclusion is that many companies, particularly those serving large metropolitan areas, will continue to operate d.c. systems. In fact, several of the larger companies have no intention whatsoever of supplanting the direct current. Direct current systems have, however, undergone substantial improvements through the use of automatic equipment and load limiting features, which have been introduced within recent years.

One interesting development, from an American standpoint, is the increasing use of the mercury arc rectifier. Three companies have purchased 250 and 600-v. mercury arc rectifiers of foreign make for use in Edison and railway service. The Commonwealth Edison Co. has purchased two 500-kw., 1500-v. units for railway work. The General Electric Co. is now making up a 500-kw., 600-v. equipment and is planning the manufacture of both 1500 and 3000-v. equipments.

In the field of low voltage direct current work, one of the most outstanding developments has been the con-

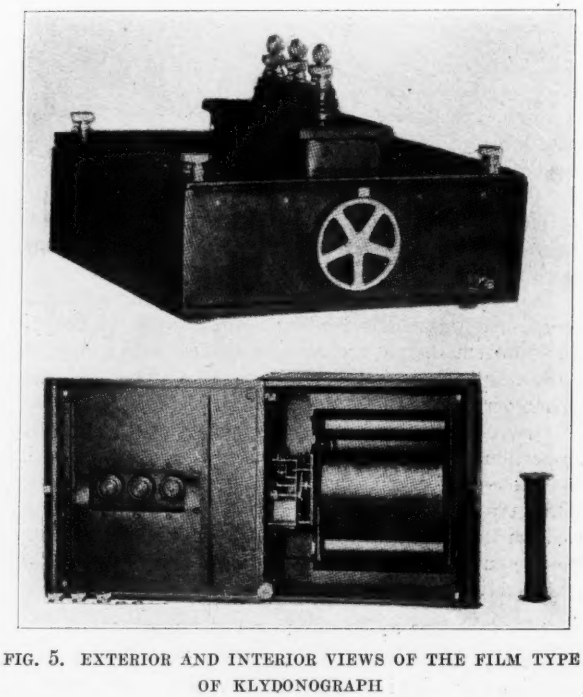


FIG. 5. EXTERIOR AND INTERIOR VIEWS OF THE FILM TYPE OF KLYDONOGRAPH

struction of a high speed circuit breaker which, up to this time, had been confined to protection of higher voltage equipment. The breaker closing mechanism is operated by a motor, thus requiring a lower value of operating current than would be necessary with a solenoid type breaker. The contacts in this device consist of a number of brushes connected in parallel to give sufficient contact area with relatively low mass. As a result, this breaker requires considerably less time for operation than one of the ordinary spring actuated type.

A modified breaker of this type has been developed for the Commonwealth Edison Company. A part of the main contacts has been insulated from the balance and used for breaking the current in the neutral of the system. In the breaker illustrated in Fig. 2 the main contacts are rated 16,000 amp. and the neutral contacts 4000 amp.

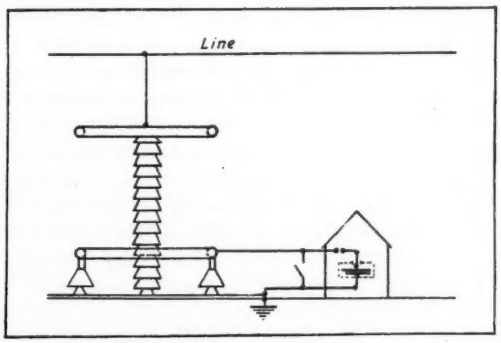


FIG. 4. DIAGRAMMATIC SKETCH SHOWING ELECTROSTATIC POTENTIOMETER FOR SECURING INSTRUMENT VOLTAGES

Some operating difficulties have been experienced in paralleling large transformers of similar ratings, due to variations in impedance values. This was because the purchase specifications did not stipulate the requirements for parallel operation. Impedance variations of 10 per cent have been noted with transformers furnished under ordinary specified values of impedance and variations of 30 per cent have occurred when no definite impedance was specified. Manufacturers have stated that with the present variations in voltage ratings and tap windings, transformer design require 10 per cent tolerances in the impedance values. Operating men feel that this range is too much for practical purposes. Caution should, therefore, be used in specifying more exactly the impedance values desired in transformers which are subject to parallel operation.

During the last few years, questions have been raised as to the safe capacity of a water cooled transformer when operated without water. In the absence of sufficient performance data, half of full load capacity has been considered as being safe.

Some difficulty has been experienced through congealing of oil in transformers which have been subjected to extremely low temperatures. Several cases have been reported of oil freezing in the pipe connection between the transformer and the conservator tank. To overcome this difficulty, surge pipes have been covered with a heavy lagging of heat insulating material which, in some cases, was supplemented with a small electric heater.

Among the largest self-cooling transformers built are those which have recently been completed by the Westinghouse Electric & Manufacturing Co. for the Public Service Production Co. of New Jersey. This installation consists of eight large single-phase, self-cooling transformers with detachable radiators. They form two banks of 45,000 kv.a. each with a spare unit for each bank and are used for stepping down from 132,000 v. to 26,400 v.

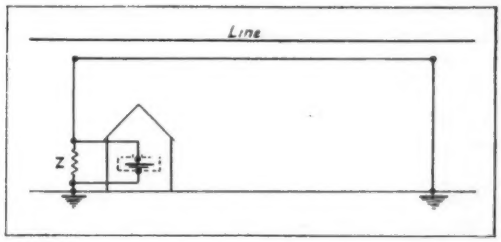


FIG. 6. CONNECTION DIAGRAM FOR COUPLING INSTRUMENT TO ANTENNA TO DETERMINE STEEPNESS OF WAVE FRONT

The first installation of a bank of Westinghouse transformers with Inertaire equipment has been operating successfully for several months; 104 Inertaire equipped transformers, aggregating 730,000 kv.a. had been bought by 13 operating companies up to December 15, 1924.

In connection with the use of the klydonograph, the Consumers Power Co. has submitted an interesting report of tests used on its 140-kv. system, which is ungrounded. Klydonographs were installed at four locations. Each installation consisted of three instruments, one for each phase. At one station an additional instrument was connected to a counterpoise consisting of a wire coupled to the line conductors, as shown in Fig. 6, and which was used to determine the steepness of wave front. To date, surges ranging from 312 kv. to 400 crest kv. have been recorded during storms. In one case, a momentary current caused a surge ranging from 181 kv. at one end of the line to 246 kv. at the other end of the line. Another interesting record was obtained when a telephone lead swung into the 140-kv. line at about the halfway point momentarily grounding one phase. Surges ranging from 202 kv. to 400 kv. were recorded on the ungrounded phases, those at the ends of the line being much greater than those at a point approximately halfway between the disturbance and the end of the line each way. Figures 7 and 8 show records taken during system disturbances.

Interest in the "chain connected" type of testing transformers is shown by the orders which have been received by the General Electric Co. by various operating companies and testing laboratories in America and Europe. The installations furnished can be expanded by the addition of one or more units to give 1,000,000 v. Herein lies one of the chief advantages of this type of transformer. The

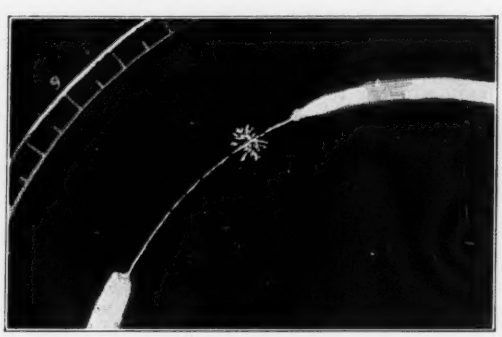


FIG. 7. POSITIVE DISCHARGE ABOUT 400,000 V.

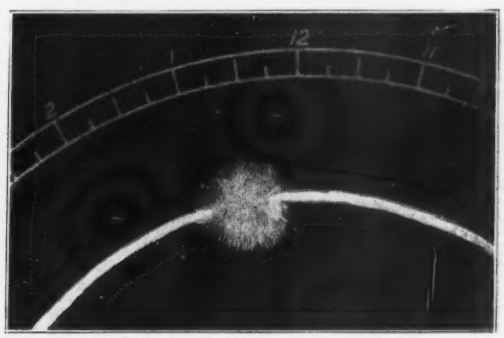


FIG. 8. A.C. DISCHARGE ABOUT 400,000 V.

equipment can be installed in units and increased as needed until 1,000,000 v. or over has been reached. After three transformers have been installed, they can be connected 3-phase, which is of advantage in many kinds of testing.

Figure 3 shows the connection for three chain connected transformers giving 1,050,000 v.

Circuit Breakers and Protective Equipment

Data were collected concerning the practice and experience with regard to the value of mufflers on indoor and outdoor oil circuit breakers. Twenty-two companies reported satisfactory results from the use of mufflers, particularly on indoor breakers. Many breakers of old design, which were originally supplied without mufflers or oil throwing preventive features, have been rebuilt by strengthening the tanks and adding mufflers.

With regard to the venting of oil circuit breakers to relieve the tanks of pressure during operation, four companies report that they extend the individual vent pipes outside of the building. Five extend these pipes outside of the room and nine extend them only through the walls of the oil switch. In all cases of venting, it is advisable to extend the header well beyond any live buses or live breaker mechanism parts from which an arc might accidentally be drawn. The gas as it is exhausted becomes highly explosive when sufficient oxygen from the atmosphere combines with it. Caution should be exercised in preventing vent pipe headers from extending across opposite phase compartments in such a manner as to reduce existing clearances between opposite phase conductors.

Measurement of Transient Voltage Disturbances

In order to measure the transient voltage disturbance on an alternating current system, the Westinghouse Co. has developed an instrument which it terms "The Klydonograph." Several instruments had been tried before, but none proved satisfactory, due to the fact that they had time lag, were not graphical, indicated only maximum values, were excessively expensive, or introduced hazards to the line. The klydonograph, it is claimed, satisfactorily answers all of the above objections.

This instrument is connected to the system by means of an electrostatic potentiometer, as shown in Fig. 4. The potentiometer is used to reduce all voltages, normal as well as abnormal, by a fixed percentage. The klydonograph determines not only the magnitude of the voltage waves but also polarity, steepness of wave front and the direction in which the surge is traveling. All records are made on a photographic plate or film. The principle of operation of this instrument was discovered in 1777, in the early days of electrical development. It makes use of Lichtenburg figures, named for their discoverer. Dr. Lichtenburg found that on discharging a condenser, such as a Leyden jar, across a spark gap onto a terminal in contact with an insulating plate placed between this terminal and the ground plate, and then sprinkling powder on the insulating plate, that the powder would arrange itself in the form of a figure that had certain peculiar appearances. By using powders of different colors beautiful figures could be produced, the figure produced by the positive charge being entirely different than that produced by the negative charge. A century later it was found that on replacing the insulating plate with a sensitized photographic plate, the emulsion being in contact with the terminal, the photographic plate retained the image of a Lichtenburg figure.

Since their discovery, the Lichtenburg figures have been studied by many investigators. It has been found that the diameter of the Lichtenburg figure is a clue to the voltage impressing the image on the photographic plate.

In the Klydonograph the image is made on a circular photographic plate which revolves slowly between the high voltage terminals or on a roll film, driven by a clock. In this way a continuous record of line conditions is given. When a voltage surge occurs not only the time of its occurrence is indicated but also its magnitude, steepness of wave front and direction of travel. Figure 5 shows exterior and interior views of the film type klydonograph.

Evolution of the Synchronous Motor*

Discussion of Development of Present Synchronous Motors and Their Salient Features. By Theo Schou

ALTHOUGH the a.c. generator made its appearance some 100 yr. ago and although we now recognize alternating current as the foundation of the electrical industry, this fact was not recognized until some 35 yr. ago and the word synchronous is of much more recent date. The simplest form of alternator would be a coil rotating in the magnetic field of the earth, a coil of 1000 turns, 3 ft. diameter and at 8000 r.p.m. on a horizontal shaft being able to generate 100 v.

Even as late as 1878, Count du Moncel said, "The (a.c.) electromotive force is susceptible of application only in very narrow limits, which cannot exceed those of clockwork." And of motors he says, "Up to the present time no motor has equaled 1 hp." In 1881, the transmission of 5 hp. over 3 mi. with a loss of 50 per cent of the power was the maximum of development.

In 1885, Thomson built an improved alternator and in 1886 a transformer, the rating being in the lights they would carry, not in kw. The capacity was from 50 to 200 kw. and the frequency 125 and 133 cycles per second. Solid cast-iron frames and pole pieces got the machines literally into hot water and the flat coils placed on the outside of a smooth armature core were continually getting injured by something falling on them or by rubbing on the pole pieces.

Naturally, laminated pole pieces, slotted armatures and imbedded coils were devised, but polyphase machines were not produced until 1887, when Tesla came to the front with his invention of the polyphase motor. This brought out the monocyclic generator of Dr. Steinmetz in which a separate winding was displaced in phase from the main winding to take care of the comparatively light polyphase motor load which was in use up to that time. After 1900, the ever-increasing demand for power brought about the polyphase generator as a standard and lighting circuits were run more and more from polyphase circuits.

Advantages of the revolving field type over the revolving armature were apparent in permitting the handling of higher voltages and greater capacity, but no

*Abstract of an address before the N.A.S.E. convention at St Paul.

**Chief engineer of Ideal Electric and Mfg. Co., Mansfield, Ohio.

voltage regulator was available and specifications calling for 5 to 6 per cent variation were common which meant an under rated machine. So compensated polyphase generators became the leaders, but were complicated and required great skill in operation.

Instruments such as circuit breakers, lightning arrestors, measuring devices were developed, also the problem of synchronous paralleling of generators was solved, but one of the most valuable inventions was the voltage regulator. This made possible better, less costly machines and better operation, and I always have felt that Tirrill has not been given proper credit for the value of his contribution to the art of a.c. operation.

Limit of Generator Size

Since 1896, when the first work was done on turbo-generators, the development has been rapid. Machines of

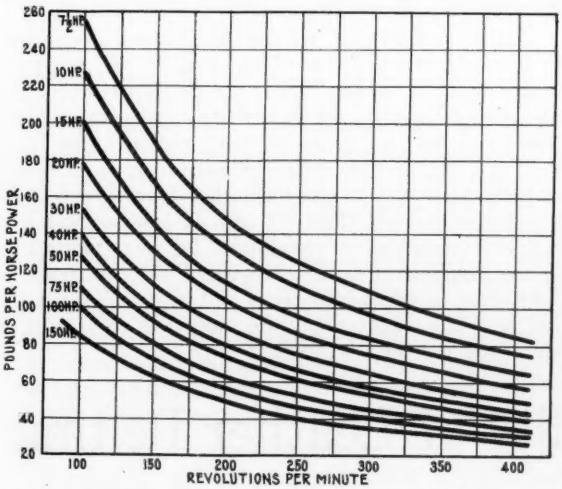


FIG. 1. WEIGHT PER HP. INCREASES RAPIDLY WITH LOWERED SPEED IN SMALL MOTORS

today weigh only 1/5 as much as those of like capacity in the early days, with corresponding reduction in space occupied. But a limit is set to peripheral speeds, which now approach 5 mi. a minute in alternators and 10 mi. a minute in turbines, by the materials available. The largest single unit to date is at the Goldberg Works near Cologne, Germany; it is 65,000 kva., 6600 volts, 1000 r.p.m., 50 cycles. During the building up of the rotor and winding, stresses are produced in all parts so great as to exceed those later set up by centrifugal force, so that there is no possibility of changing balance even at overspeeds as high as 50 per cent.

Adaptation of Synchronous Motors

Twenty years ago the synchronous motor was thought little of as a power device but, as its value in correcting power factor was recognized, it was used as a condenser, floating on the line, also as a motor for motor-generator sets, when the starting load was light. It was, however, recognized that it had splendid characteristics as a power motor especially for low speeds, for which it was practically out of the question to build induction motors. The serious objection was the poor starting torque, but design of a motor as a motor instead of a modified alternating-current generator has overcome this fault so that synchronous motors of today compare well in starting characteristics with ordinary squirrel cage designs and special designs are even better than slip-ring motors.

Several years ago a good field was found for synchronous motors in connection to reciprocating machines such as ammonia and air compressors. When provided with full size bypass, a compressor has but slight starting and pull-in torque and the rotor of the motor gives a satisfactory flywheel effect.

Investigation of inrush starting current phenomena led to the "across the line" motor of which the Ideal Electric and Mfg. Co. was the first successful pioneer to start a large synchronous motor, economically, direct from the line, with full automatic control. Of late, this method has become popular, almost standard, as it eliminates auto-transformers, tandem switches and the human element in judging when to throw over onto full voltage. This method insures against shocks which may wreck a direct-connected unit and against line disturbances which arise when a motor is disconnected and reconnected to the line.

Means of Excitation

Excitation of commercial motors is by direct current at 125 or 250 v. from belted, direct-connected or motor-driven exciter. It has been the ambition of many de-

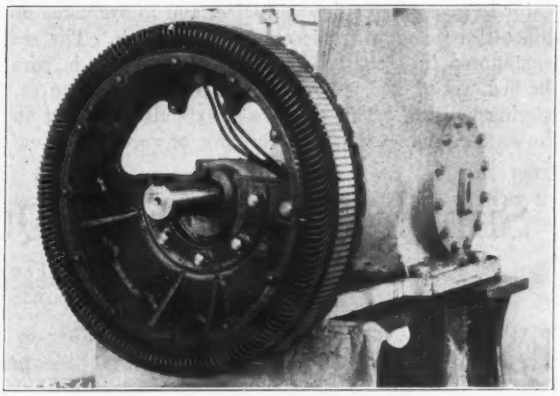


FIG. 2. MOUNTING THE STATOR ON A CRADLE SUPPORT INSURES CENTERING AND RIGIDITY

signers to get rid of the exciter, the best results, so far as the writer knows, having been obtained by the Wagner Electric Co. in the Fynn-Weichsel motor.

Special Design Motors

This motor has good starting and operating characteristics and should become popular, if cost does not prove too serious a handicap. So far as the writer knows, it is at present made only for smaller ratings at comparatively high speeds.

Another special design is the flywheel motor, adapted equally well for small alternators and for direct connecting to reciprocating units, such as compressors and pumps. Direct connection has an advantage over belting as to space, upkeep and efficiency, but has an obstacle in the high cost of the motor. The reason for this cost is apparent from Fig. 1 which shows the pounds per horsepower for various speeds and ratings. The weight per horsepower increases rapidly as the speed decreases.

Overhung motors have been used for this class of work and in a late design, the rotor is placed outside the

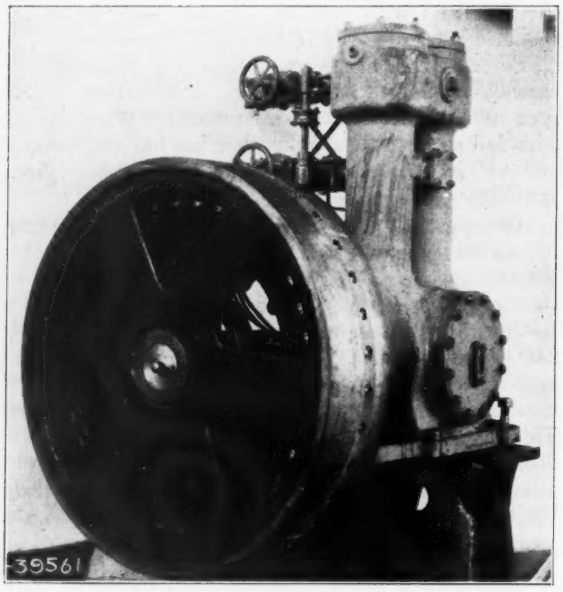


FIG. 3. PLACING THE ROTOR OUTSIDE THE STATOR HAS ADVANTAGES

stator to give greater flywheel effect and to overcome other difficulties found with the older construction. The stator is mounted in a cradle support, Fig. 2, which is part of the bed casting and is bored out at the same setting as the bearing housing. This cradle seat extends somewhat above the half circle, so that any shifting upward is prevented. Exact machining of the stator spider to fit the cradle insures a uniform air gap which is essential with small synchronous machines. The rotor, which is mounted on the shaft extension with a pulley and key fit, has all vital parts inside where they are protected from injury and has the outside crowned so that it may serve as a pulley for a belt. Figure 3 shows a complete motor and compressor unit with a 30-hp. motor at 200 r.p.m., 60 cycles and a 7½ by 7½-in. compressor.

In this design, there is increased space between the poles with less field leakage, which requires less exciter capacity. At the same time, the flywheel effect is increased, with the same weight of rotor, and extra weight can easily be added to the rim, if more flywheel is needed, up to the limit of the overhung shaft and bearing. As the unit is self-contained, it can be shipped to the customer ready to run without requiring special foundations or erection for the motor.

As to the future of synchronous motors, if one were to judge by the progress of the past 25 yr., wonderful things might be expected. But the sad fact remains that, with all our research, we do not know the nature of electricity nor have we found anything radically new in respect to fundamental laws. Electrical machine design methods have been in use for such a long time that one would hardly doubt them. I believe, however, that they will be investigated in the future, for some matters are in too complicated form to represent the real truth. I believe the electrical industry is still in its childhood days and that this ought to inspire every one of us with an optimistic view of the future.

Simple Tests Show Quality of Leather Belting

LOCATION ON ANIMAL FROM WHICH BELT WAS TAKEN AND IMPROPER TANNING EASILY DETERMINED. BY LOUIS W. ARNY*

EFFORTS to make possible a closer discrimination between qualities of leather belting have been made through the establishment of standard specifications for leather belting, in collaboration between The Leather Belting Exchange and the United States Bureau of Standards at Washington. These specifications go into all the details of quality and where the material is properly inspected and tested, discrimination between the good and the bad is made with certainty. The application of these tests, however, is difficult, except for those concerns who have testing laboratories.

These specifications require certain qualities, and they provide numerous tests for determining these qualities. All of these tests are necessary to classify the quality of the belt, but in many cases definite inferiority can be decided by the use of a few sample tests, without going far into the specifications.

Belting leather is made from the hide of beef cattle, preferably the steer, this hide being a fibrous covering provided by nature for the protection of the animal. It is composed of an inner membrane which lies next to the flesh and an outer layer of finer fiber in which the hair is embedded. Between this inner layer of membrane and outer layer of fiber are millions of little fibers, varying in length on different parts of the animal but all attached either to the membrane or to the outer fiber, and to each other, forming a mat or felt of fibers, which in motion work on each other, and which possess great strength. In the process of tanning, this fibrous material is changed into a wonderfully strong and flexible substance which is not affected by the ordinary solvents of nature—air, water, etc., or by fungus or bacterial influences.

Over the backbone of the animal the fibers are shorter and denser, of slightly less tensile strength and less stretch, but they change in their nature as we proceed down the side of the animal from the backbone. About half way down we find the fibers longer, not so dense, and stronger, and farther toward the belly of the animal the fibers are still longer, with a higher tensile strength, but with more stretch and less elasticity. It is desirable, therefore, that belts should be made of the upper half of the side of the animal, and this constitutes, roughly, according to the size of the animal, a strip equivalent to about 15 in. each side of the backbone. In the examination of belting, the question therefore becomes important whether the belt is made of that portion above this line, drawn 15 in. from the backbone, or whether it is made of that portion lying farther down, and nearer the belly.

This can be determined with a reasonable degree of accuracy by the "piping" tests provided in the specifications. This is based on the fact that the leather in the lower half of the hide, with its longer and looser fibers,

* Secretary, The Leather Belting Exchange.

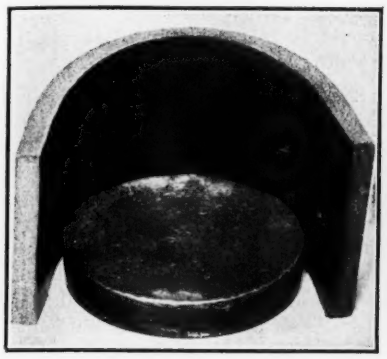


FIG. 1. GOOD LEATHER DOES NOT "PIPE" WHEN BENT OVER PROPER FORM

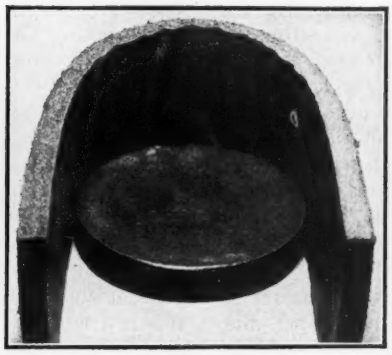


FIG. 2. AN EXAGGERATED CASE OF PIPED GRAIN OF POOR LEATHER

FIG. 3. POOR LEATHER SHOWING SURFACE OR GRAIN CRACKS WHEN BENT OVER FORM

is softer and spongier than the upper part and that the grain surface of the leather is not so firmly attached to the inner fiber, and in bending this leather it will develop usually into wrinkles or "pipes" in the grain. It is possible to produce "pipes" in almost any piece of leather by bending it often enough and close enough, and applying sufficient force, but to make the test perfectly fair the specifications provide that a single leather belt shall not show pipes, or piping, when bent over a form 2 in. in diameter; or a double belt 7/64 in. thick when bent over a form 4 in. in diameter; or a double belt 19/64 in. thick when bent over a form 6 in. in diameter. Practically all belly stock will show piping under this test, even when it has been rolled hard to prevent its showing, hence it is not desirable for belting purposes. Occasionally, also, pieces from the upper part of the hide will show piping under this test, but regardless of the part of the hide from which the piece is taken, the presence of piping indicates a loose grain and a flabby fiber in the leather, which is not conducive to durability in the belt, and in most cases indicates the presence of belly stock.

There is another test to be applied by bending the leather over the same form, with the grain side outside, to detect cracking in the grain, and if this test shows that the leather cracks, that is, if it develops a series of minute cracks running across the width of the belt, it may be determined that the material either is not properly tanned, or is not properly curried, and that it is not suitable for belts.

It is not possible to determine much about the quality of the leather by its "feel," because the makers of inferior commercial grades have learned the trick of rolling and jacking their leather, and filling it with materials to solidify it, that makes the "feel" deceptive, but the piping test above described, if properly applied, will expose it.

The next important test is the tensile strength test, though it is important only in connection with other tests, since the poorest part of the hide shows the greatest tensile strength. Since hides vary so much in substance and strength in their different parts, it is not possible to test one piece of leather and to say that that is the tensile strength of the belt. The specifications meet this condition by providing that the test shall consist of five test specimens, selected at random from different parts of the sample being examined, and that these shall average 3750 lb. per square inch of section, and that the minimum shall not be less than 3000 lb. This is an assurance against bad tanning, and will expose any leather that is burnt by any of the processes of tanning. Of course, 3750 lb. is a relatively low tensile strength for this material, for most of it will go to between 5000 and 6000 lb., but it is quite sufficient to determine that the leather is not inferior and, furthermore, it is about ten times as much stress as the belt ever will be required to withstand in actual service, so it seems to be quite sufficient.

With the tensile-strength test, the stretch or elongation test should be applied, by placing parallel gage marks

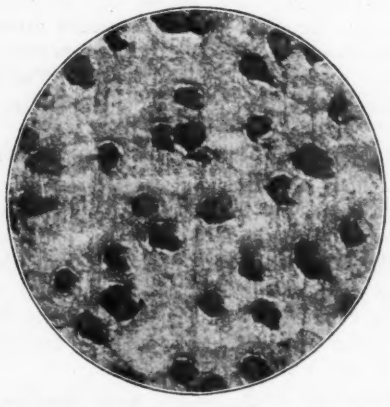


FIG. 4. TOOL MARKS ARE VISIBLE IN MAGNIFIED VIEW OF GRAIN OF LEATHER AFTER VIOLENT ROLLING OR JACKING

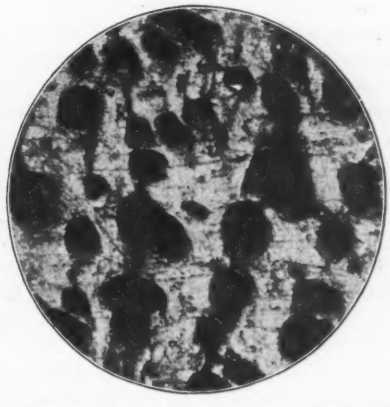


FIG. 5. MAGNIFIED VIEW OF NATURAL GRAIN OF LEATHER SHOWING FIBROUS CUSHIONS WHICH GRIP THE PULLEY

2 in. apart on the test specimen, and stopping the machine when it has reached 2500 lb., and measuring the elongation. This must not exceed 15 per cent, and this is quite liberal to the belt, for most of the better belts will not elongate to this extent. A large tensile strength accompanied by a large stretch and small elasticity also indicates belly stock, while tensile strength somewhat less, accompanied by not over 15 per cent stretch, and better elasticity, indicates center stock. These tests will determine the part of the hide from which the belt has been made.

Chemical tests provided in these specifications are interesting and, where accurate results are desired, they are necessary, but the tests already enumerated will demonstrate whether a leather belt is cut from the upper or lower half of the side, and whether it may be depended upon for good service in the shop, because if it is markedly defective under the chemical tests, such deficiencies probably would show in some one of the physical tests named.

Another requisite of the good belt is that it shall be of the proper thickness. Sometimes this is designated by weights per square foot, but care should be taken that the belts offered should measure in thickness, or should weigh, according to the specification of purchase. Medium or regular singles, for instance, should measure from 10/64 in. to 12/64 in.; that is, the narrow sizes, 1½ in. and 2 in. should measure 10/64 in., and the wider sizes, 4 to 6 in., should measure 12/64 in., and weigh from 14 to 16 oz. per sq. ft. This especially is necessary in buying double belts. Care should be taken, also, that the belts shall be accurate in width, and variations in width of more than 1 per cent are not tolerable.

Belts must be purchased for their substantiality but a belt may be made of excellent leather and still be inefficient as a transmitter of power, because the latter quality depends almost entirely on the treatment which has been given the grain or hair side. Many buyers think that if the belt feels firm and solid it must be leather of a high quality and, if it is finished highly, with a brilliant gloss, it appeals to the eye as well finished material, but this is a mistake. The firmest and most solid leather is attained by heavy rolling and jacking, the high polish by jacking, and both are destructive of the fibrous grain surface. The contact of the belt with the pulley is formed by this elastic cushion of the natural grain, and when this is destroyed by mechanical action, the capacity for making this close pulley contact is much reduced, and under test the rolled and jacked leather transmits little more than half as much power as that with a natural finish. The best belt makers, those who have studied belts technically and who have had the advantage of the work which has been done on these subjects by The Leather Belting Exchange Foundation, take care to preserve the characteristics of the natural grain, so that their belts shall be not only durable, but shall be able to carry a full load on installation, and a large overload after they have run a few hours.

Revamping Plant Cuts Coal Bill 100 Per Cent

Replacement of Obsolete by Modern Equipment in St. Louis Plant Reduces Coal Burned 100 T. a Month

SAVING ONE hundred per cent of the coal bill sounds more like a pipe dream or the result of indulging in too much "white mule" than the statement of a serious engineering fact, and had we not been convinced of the accuracy of the assertion, we would be inclined to disbelieve it ourselves.

"Very well, then," you say, "supposing it is true. Where's the catch?"

And that's the strange thing about this story, there is no catch. It's the straightforward, honest-to-goodness truth. Since the St. Louis Coffin Co. revamped their power plant and factory they are actually saving practically their entire coal bill. Whereas before the alterations were made they burned 100 T. of coal a month in addition to the wood refuse from the factory, now they burn only the wood refuse. Furthermore, in the face of this remarkable saving of coal the power output to the factory has been increased approximately 25 per cent.

It is merely another case illustrative of the economies that may be secured by the installation of modern power equipment in place of the old. While the savings effected at this plant are, without question, unusual and are partly accounted for by the run-down condition of the former equipment, there are many plants in existence where similar economies could be obtained by employing similar methods.

There is a prevailing notion among certain owners of power plants that as long as an engine or other piece of power plant equipment keeps running and is in good operating condition, it is efficient and that it would not pay to discard it for a new machine. Of course, to anybody connected with the power plant industry and who had followed its advances, the fallacy of such reasoning is obvious. The efficiency of certain pieces of power plant equipment has been greatly increased during the past 10 years and the installation of such equipment in place of an absolute machine, no matter how smoothly it operates, will result in savings.

The original power plant at the St. Louis Coffin Company consisted of a 250-hp. Corliss engine belted to the line-shafting in the factory. It also drove a small d.c. generator for operating a few small motors in the plant, and a 60 kw. a.c. generator for the spot welders; on the whole, however, the plant was mechanically driven. The engine exhausted into a gravity return heating system, and in winter carried 10 lb. back pressure. The dry kilns in the factory were connected to a pumping trap.

Engine Was Located 200 Ft. From Boilers

An extremely undesirable feature connected with the engine installation, was the fact that it was located in the opposite corner of the building from the boiler room. If the installers had deliberately tried to locate the engine as far away from the boilers as possible, they could not have done a better job than they had. There were some 200 ft. of steam line between the boilers and the engine and most of this was in poor condition.

Two 72-in. by 20-ft. boilers were installed. These units, which are still being used at the present time, will be replaced this summer by two 250-hp. water tube boil-

ers, are rated at only 110-hp., due to the fact that they were fitted with 6-in. flues.

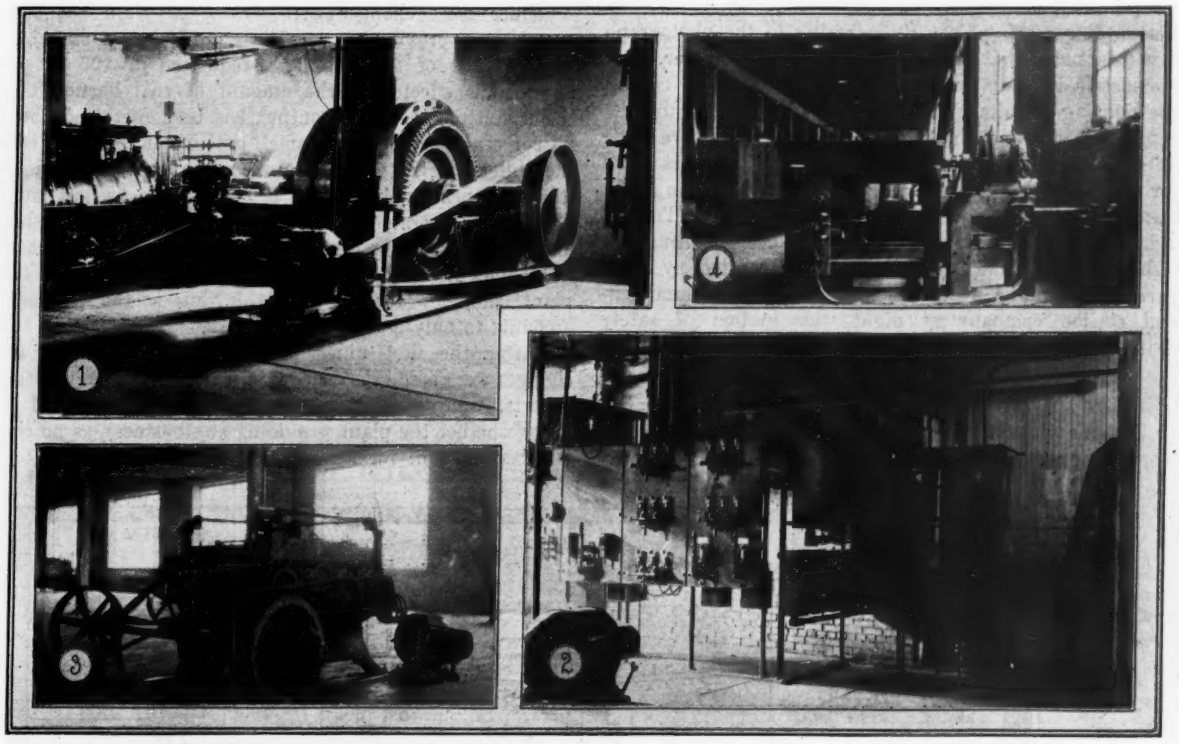
In rehabilitating this plant, which was done by the Larkin Engineering Co. of St. Louis, the first obvious change was the electrification of the factory. All the machines, and there were a large number of them, were driven by belts through line shafting. This had not been maintained in the best of condition and the friction load was excessive, in fact, it amounted to as much as 40 per cent of the total belt load.

One of the first steps in the work was the construction of a new factory building in which all of the wood-working machines were equipped with electric motors. This part of the work was, of course, by far the largest part of the job, and the application of the correct types

All high pressure piping was thoroughly overhauled, leaking joints and valves repaired, drips and drains installed where necessary and the whole covered with 85 per cent magnesia covering.

The boilers were cleaned of dust and scale and the brickwork of the furnaces repaired. This cleaning resulted directly in the boiler inspector regranting a boiler pressure of 125 lb.

The heating system installed in the new factory building is a Warren Webster Vacuum system using Nash vacuum pumps. All the returns from the heating system are passed back into a 500-hp. Cochrane feed water heater. Make-up water is from the city supply. This is good water and requires no treatment. It is heated to a temperature of 200 deg. before delivery into the boilers.



FIGS. 1-4. VIEWS IN THE FACTORY AND POWER PLANT OF THE ST. LOUIS COFFIN COMPANY

Fig. 1. The new uniflow engine and generator. Fig. 2. The switchboard, showing the safety switches at the right.

Figs. 3 and 4. Two views in the factory showing the types of wood-working machinery used.

of motors on the various machines, many of which require two and three separate motors, each of which run at a different speed, was a problem of considerable magnitude.

Corliss Engine Replaced by Uniflow

The initial step in modernizing the power plant consisted in locating a new engine room adjacent to the boiler room. This at once eliminated the loss involved in the 200 ft. of steam line present under the old conditions. Next, the Corliss engine was discarded and a new uniflow engine installed in its place. This unit is a 400-hp. Skinner Universal Uniflow engine operating on 125 lb. steam pressure and exhausting under 1.5 lb. back pressure. It is direct connected to a 375 kv.a., 3 phase, 220 v., General Electric Co., generator with excitation furnished by a separate belt-driven exciter.

The switchboard for controlling and distributing the electrical energy is shown in Fig. 2. For the generator and outgoing feeder lines, air break circuit breakers were employed. The chief reason for using this type of breaker in preference to the usual oil immersed type, was the low initial cost. Of course, simple knife switches, together with fuses, would have been still more economical, but this form of equipment was not deemed advisable due to the possibility of the occurrence of single phasing. Three oil circuit breakers are provided, one for a 220-hp. frequency changer set in the factory and the other two for the spot welding machines installed in the metal working shop. The two spot welders are rated at 25 kw. single phase.

Equipment on the switchboard is all of General Electric Co. manufacture and the board was designed by the

FIG. 6. SYNCHRONOUS MOTOR DRIVING THE SHAVINGS FAN AND THE 60-CYCLE GENERATOR

Larkin Engineering Co. By referring to the photograph it will be noted that to the right of the board proper, there are installed a number of safety switches. These control the lighting circuits in the factory buildings and the elevator motors. At a plant of this type, deliveries are made during the entire 24 hr. of the day. Undertakers come for caskets at any time during the night and the night watchman at the plant takes care of the orders. To provide an absolutely fool-proof system for controlling the lights and elevators, which are often operated by inexperienced help and which are supplied from the local central station company at night, this system of safety switches was installed.

Frequency Changer Set

Reference was made to the fact that some of the woodworking machinery in the factory required different speed motors. In order to obtain the high speed necessary, a frequency of 100 cycles is used for such motors. This high frequency current is supplied by a generator driven by a 220-hp. synchronous motor. This outfit is installed on a platform in the woodworking shop. The motor, in addition to driving the 100-cycle generator also is belted to a shavings fan, used to transport wood waste to the boiler room. This fan is rated at about 65 hp. The generator is a 60-kw., 60-cycle, 900-r.p.m. machine speeded up to 1500 r.p.m. so as to give a frequency of 100 cycles at 385 v.

The synchronous motor was purposely selected a little larger than necessary to handle the load in order that it might be used for power-factor correction purposes. The power factor is kept close to unity at all times.

Results of Changes

Since these changes were made, the plant has been operating approximately one year, and as was stated in another part of this article, a reduction of 100 T. per month was effected in the amount of coal burned. In the meantime the power output has been increased about 25 per cent. Except for a small amount of coal fired into the boilers during the noon hour when no wood waste is available, practically no coal is used at the present time. The boilers operate up to the capacity of the wood shop and for this reason, when the shop shuts down at noon, it becomes necessary to use a small amount of coal. The plant load, however, is off at this time so the coal used amounts to only a few tons a month.

After the first ninety days of operation after the changes were made the owners, in looking over the monthly reports, wanted to know what was wrong—wanted to know whether the plant was doing any business, as no coal had been bought for three months.

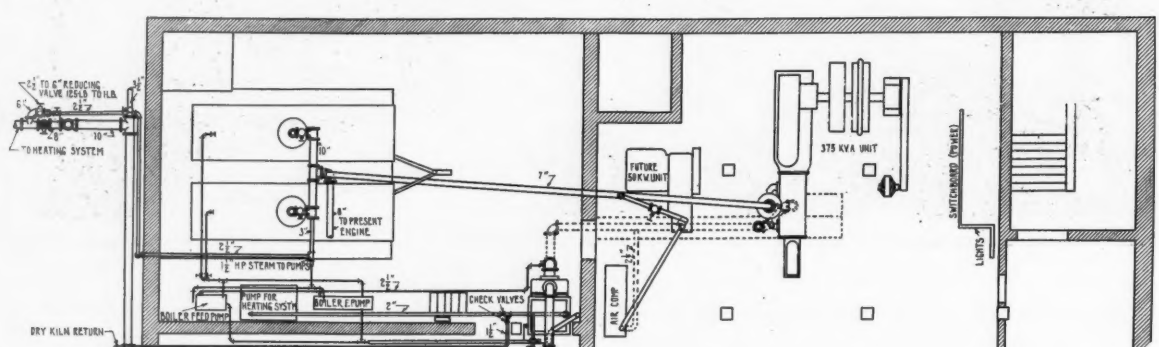


FIG. 5. PLAN AND ELEVATION OF THE POWER PLANT

Spray Cooling Systems for Ammonia Condensers

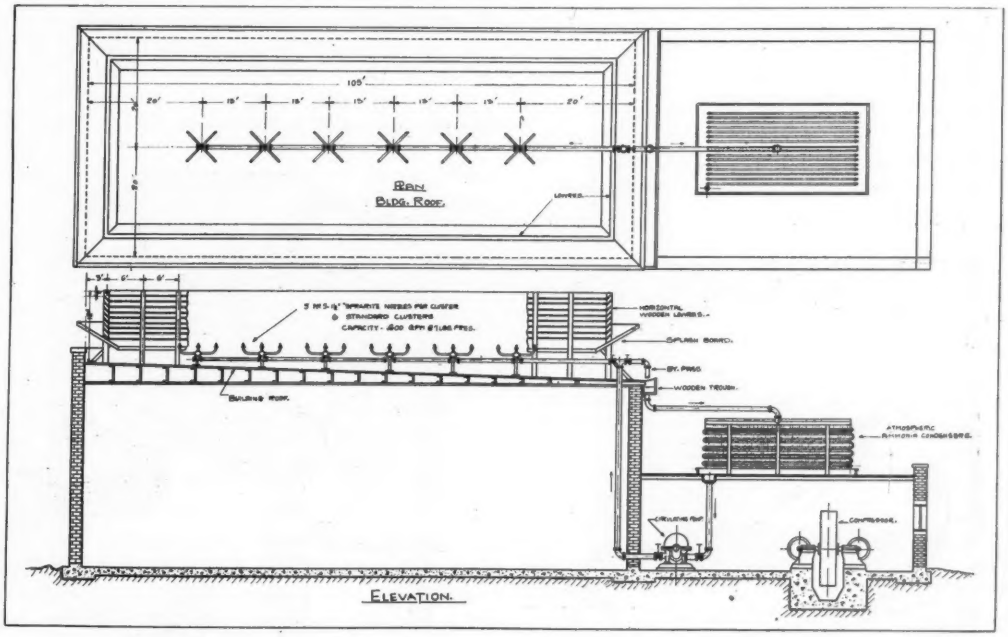
TESTS OF SEVERAL SPRAY SYSTEMS SHOW THAT THEY CAN COOL CONDENSER WATER TO WITHIN 4 OR 5 DEG. OF WET BULB TEMPERATURE. BY C. R. KRANZ

SPRAY PONDS which can be installed either upon the ground or building roofs are proving exceptionally popular in the refrigerating industry, due in particular to high cooling efficiency obtained with small initial and maintenance expense.

In the past seven or eight years thousands of these installations have been made for plants ranging in capacity from 20 T. of refrigeration up to several hnudred. Careful tests made on many of the most prominent installations show that it is possible to return water to ammonia condensers by means of sprays at an average temperature within about 4 or 5 deg. of that shown by the wet bulb thermometer. The efficiency of any artificial cooling device is determined by its approach to the wet bulb thermometer, which in most localities of the United States in summer months will average somewhere in the neighborhood of 68 to 70 deg., thus resulting in final water temperatures of about 73 to 75 deg. to condensers. Ordinarily, spray systems of good design and construction can be installed at less than one-third the expense of cooling towers of the same capacity and it is usually possible to operate under lower pumping heads for water distribution, by reason of the fact that spray nozzles are operated at a pressure of 7 lb. It has been found after making a careful survey of the industry that an artificial cooling system will generally pay for itself in a few months as compared with the cost of purchasing water from city mains. The general statement might be made that this water will cost on an average of 7 to 8 cents per 1000 gal.

For spray pond service the amount of water circulated will average about 4 gal. per minute for each ton of refrigeration, resulting in a temperature rise of 6 to 8 deg. Using a water ratio of 3 or even less, which is oftentimes necessary by reason of limited space, the heat transfer will be correspondingly higher, but in order to approach the wet bulb temperature within 4 or 5 deg., this temperature rise should be held within certain limits and should not exceed 14 deg.

Tests on 18 spray systems of normal selection in the Chicago district have been made, the results being shown in the accompanying table hereunder. The accompanying sketch shows a spray pond of good design and construction, installed on a roof to supply cooling water for an ammonia condenser. Other arrangements are possible, of course, all depending upon space available for the system and operating conditions to be met.



PLAN AND ELEVATION OF TYPICAL SPRAY COOLING SYSTEM INSTALLED IN REFRIGERATING PLANT

TABLE SHOWING RESULTS OF TESTS

ATMOSPHERIC CONDITIONS					WATER TEMPERATURES		
Dry Bulb	Wet Bulb	Humidity Pct.	Clear	Windy	Before Spraying	After Spraying	Nozzle Pressure
88	78	64	Yes	No	90	81	7 Lbs.
88	79	67	No	"	89	82	"
75	71	82	Yes	"	83	75	"
76	70	75	No	"	82	74	"
68	63	76	No	"	73	64	"
86	76	63	Yes	"	91	79.5	"
71	68	86	Yes	"	79	71	"
76	72	83	Yes	"	87	76	"
77	72	79	Yes	"	88	75	"
82	78	84	Yes	"	90	82	"
84	75	66	Yes	"	85	79	"
87	77	64	Yes	"	84	78	"
86	76	63	No	"	85	78	"
84	74	63	Yes	"	87	78	"
85	74	60	Yes	"	85	77	"
78	65	50	Yes	"	73	69	"
86	76	63	Yes	"	84	79	"
81	74	72	Yes	"	85	78	"
85	77	70	Yes	"	86	79	"
66	64	90	No	"	76	66	"
78	73	79	Yes	"	82	75	"
81	74	72	Yes	"	83	77	"
81	69	55	Yes	"	79	73	"

Dry Wood Affects Brick Work Maintenance

I HAVE READ with interest your abstract of A. S. M. E. papers presented at the Portland meeting and also the original papers in their entirety. Naturally, with the discussion on wood waste furnaces receiving so much publicity, there will be a number of new installations of similar design. It is to warn against disappointment to many power plant engineers that I have taken the liberty of pointing out a factor that has been entirely omitted from the discussions.

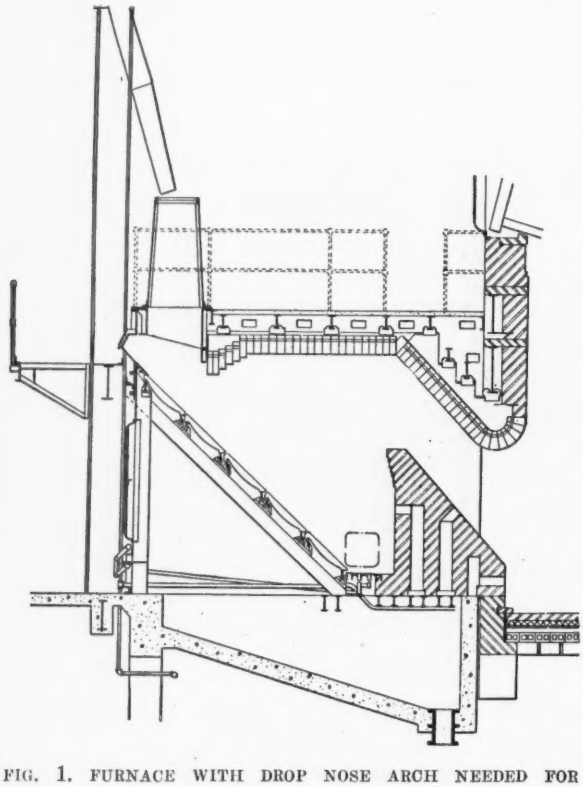


FIG. 1. FURNACE WITH DROP NOSE ARCH NEEDED FOR WET WOOD WASTE

A reading of the papers will reveal that the installations cited are all located in the Pacific Northwest and that time after time the high moisture content of the wood waste fuel is mentioned. It is also carefully pointed out that with this wet fuel furnace temperatures never exceed 2300 deg F., and often are as low as 1500 deg. F. Under such temperature conditions, furnace brickwork and arches can be quite readily maintained and will be fairly long-lived.

But in the Upper Mississippi Valley and Northeastern States are located practically all of the woodworking industries that use only kiln dried lumber. Generally, the moisture content of their waste fuel is less than 10 per cent and often as low as 5 and 6 per cent. With fuel as dry as this the furnace temperature often gets high enough actually to melt a good grade of fire brick. Under such conditions, a long retort furnace or a drop nose arch will not stand up satisfactorily.

Considerable mention has been made of salt and lime fluxes affecting the brickwork and the source of these has been explained. It is obvious that fluxing of fire brick in plants using kiln dried lumber in remanufacturing processes cannot be explained in this way. The only other logical conclusion must be that the melting of furnace brickwork is due only to high temperature—possibly 2800 deg. to 3000 deg. at times. It is, therefore, important that engineers in plants using kiln dried fuel shall not be unduly influenced by these discussions. For wet fuel the deflecting arches and retorts afford the best possible construction. For dry fuel it is necessary to do away with the deflecting arches almost entirely, since they are so hard to maintain.

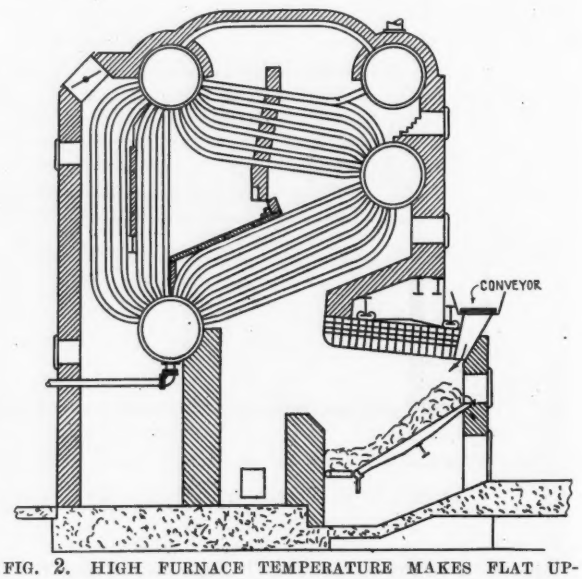


FIG. 2. HIGH FURNACE TEMPERATURE MAKES FLAT UPWARD SLOPING ARCH NECESSARY

In a large plant using kiln dried fuel, inclined grates, similar to those shown in Figs. 1 and 2, page 837, Aug. 15 issue of Power Plant Engineering, have been used with excellent results. The use of grates having hand-operated pushers and a dump plate at the back are desirable where coal must be used occasionally when the supply of wood

fuel runs short. A furnace and grate to burn coal and wood interchangeably is, at best, somewhat unsatisfactory since the fuels are so different.

A furnace designed similar to Fig. 1, but omitting the drop or declining part at the back of the arch, will give good results. The drop part of the arch would be too expensive to maintain when using dry fuel. It may appear that such a change can be made only at the expense of economy, for it is true that there will be some loss and it will also be a little difficult to get smokeless combustion without the drop arch or long retort. But proper control of continuous fuel feed and automatic damper adjustment will overcome most of these difficulties.

As for economy, a 400-hp. Kidwell boiler with a furnace, as shown in Fig. 2, operates a cross-compound Corliss non-condensing engine direct connected to an 800-kv.a. generator, including steam for all auxiliaries, at an average rate of 6 to 7 lb. of kiln dried wood waste (8 per cent moisture) per kilowatt-hour delivered at the switchboard. With the heat value of wood calculated as 40 per cent that of bituminous coal, this is the equivalent of less than 3 lb. of coal per kilowatt-hour. For 160 lb. pressure, slight superheat and about 2 lb. exhaust pressure, this is considered fairly good economy, since exhaust steam is also used for heating.

It is hoped that this information will show that poor economy is not necessary because of some limitations in furnace design. It should also be evident that a furnace ideal for wet fuel is not suitable for dry fuel. Plants using dry fuel should be cautioned about installing brickwork and arches that will be difficult, if not impossible, to maintain. Even with arch and bridge wall, as shown in Fig. 2, frequent replacement of the nose brick of the arch and top brick of the wall are necessary. It may be noted, however, that these repairs are limited to places easily accessible.

Clinton, Iowa. SEM MADSEN.

Making Old Engines Show Profit

MY ATTENTION was attracted to the article by A. F. Sheehan in the July 1 issue, as it showed an ingenious way of reducing fuel costs with only a small capital expenditure. In most industrial plants more than 15 yr. old, this plan could be applied with certain modifications. A few years ago I adopted a similar plan although slightly modified.

We had two paper machines with a combined output of 25 T. daily, one machine being considerably larger and a much later installation than the other. The smaller machine had been speeded up in an endeavor to approach the production of the larger unit and this called for an increase in the steam pressure carried in the driers since the smaller amount of drying surface was insufficient at the increased speed. To get dry paper from this machine, 35 lb. pressure was carried, whereas the larger machine delivered dry paper with a steam pressure not exceeding 5 or 6 lb. Each machine was driven by an individual four-valve Ridgway engine and each engine exhausted into its respective drier. The exhaust steam was not sufficient to maintain the required pressure, so considerable live steam was taken through a reducing valve at the proper pressure. The engines were supplied with steam at 140 lb. pressure, the small unit exhausted at 35 lb. back pressure, and the large one operated against 5 lb.

We conservatively estimated that the small machine used at least 1000 lb. of live steam per hr., reduced from 140 to 35 lb., and that the live steam consumption of the large machine, at 5 to 6 lb. pressure, was about 3000 lb. per hr. Our main power supply was furnished by a simple four-valve condensing engine rated at 300 hp., but carrying a load of 410 hp. Late cutoff caused such a high terminal pressure that the water rate was too high to be economical. With a normal load, the water rate was estimated from the indicator cards at 20 lb. per hp-hr., although at lighter loads we had obtained a rate as low as 17.5 lb.

At my suggestion, for the small cost of $1500, the company bought a second-hand, tandem-compound, high-speed engine, which had lain idle in one of the local plants for years. This engine was rated at 150 hp. and we figured that, if the 4000 lb. of steam needed for the driers could be passed through this engine and then exhausted to the driers, it would show the greatest saving, since the total drying process could be done with exhaust steam and at the same time, between 125 and 150 hp. could be developed at practically no fuel cost. In addition, the water rate of the condensing engine could be improved by transferring part of the load to the non-condensing unit.

Installation costs approximated $1000 for foundations and piping with two steam lines running from the engine to the machine room. A 4-in. line carried the main exhaust from the low-pressure cylinder to the large machine at 5 lb. pressure and a 1¼-in. bleeder line, extending from the receiver to the small machine, supplied steam at a pressure from 35 to 38 lb. A balanced valve of the quick-opening type was placed in this line and was operated by the pressure regulator on the driers.

When operating, only sufficient load was permitted on this engine to maintain 6 lb. back pressure on the large paper machine, as the relief valve was set to open at 8 lb. Approximately one-fourth of the steam was bled from the receiver and this amount could be varied at will by the machine tenders by changing the weights on the regulator. When connecting this engine to the main shaft, a clutch was used and the proper size pulleys calculated from the speeds of the two engines.

New pulleys and belt cost about $500, but an old clutch which had not been used for a long time was found satisfactory. This clutch made it possible to shut down the small unit whenever minor adjustments were necessary, since the weighted lever type of governor on the large engine allowed us to shift any amount of load to or from the small engine. When operating the small engine, we increased the tension of the governor spring in order to carry as much load as possible, since this engine had to operate at practically full load to satisfy the demand for exhaust steam. This demand was fairly constant except when changing the grade of paper and we were always advised of such changes.

With this new arrangement the small engine developed 142 hp. and the main engine was relieved of 130 hp., the difference of 12 hp. being absorbed by mechanical losses. Due to the fact that we bled 1000 lb. of live steam per hour from the receiver, the low-pressure cylinder developed less power than the high-pressure, the latter showing 82 hp. and the former only 60 hp.

Saving effected by this system was figured as follows: reducing the load on the main engine by 130 hp. saved

130 × 20 = 2600 lb. of steam per hour and, at the more favorable load carried by this engine, the water rate was reduced from 20 lb. to 18 lb. per hp-hr., making a further saving in steam of 560 lb. per hr. Coal cost $6.40 a ton delivered to the boiler room so that, assuming an average evaporation of 9 lb. of water per pound of coal, over $26 per day was saved.

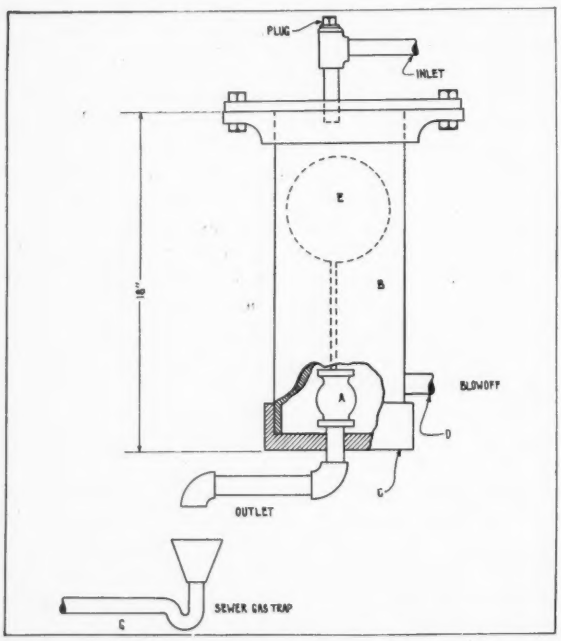
The reduction in coal costs returned the original investment of $3000 in less than five months. Even if the life of the plant is extended for only 5 yr., about $40,000 will be saved in that length of time and such a high dividend rate should be an inducement to the owners to investigate the possibility of further economies.

If the engine had been of greater capacity, we would have followed Mr. Sheehan's idea and installed a heater for raising the feed-water temperature to about 270 deg. F. by bleeding steam from the receiver but, under the circumstances, the receiver pressure would have dropped too much, if any more steam had been bled.

Chicopee, Mass. J. A. MADSEN.

Separator Trap Easily Made

IN THE August 1 issue, F. S. Rutledge suggests using steam traps on the drips from separators in exhaust steam pipes. Ordinary steam traps, of many designs, will often



LARGE SIZE PIPE WITH CHECK VALVE AND FLOAT MAKES EXCELLENT SEPARATOR TRAP

prove unsatisfactory for the purpose, because of the small valve opening. Such openings soon become choked up with thickened cylinder oil and other material.

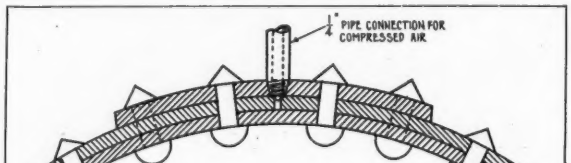
When such a trap stops discharging and the exhaust steam is used in an open heater, the oil in the exhaust will pass into the heater and ultimately reach the boilers. A safe trap, designed for such location, may be purchased or one can be made at a moderate cost as shown in the accompanying sketch. A is a ½-in. check valve, to the seat of which is attached a rod and float, the upward movement of the float E opening the valve. The body B is a piece of pipe 6 in. or more in diameter. C is made from a pipe cap and such a cap may also be used at the top, if desired, but the use of the flanges makes it possible to take the trap apart with little trouble. Holes must be provided for the inlet and outlet and blowoff pipes. The outlet pipe discharges into a funnel shaped sewer gas trap and thence to the sewer or to a tank where the oil may be collected and filtered for re-use.

It is not necessary to provide the reservoir with a gage glass, since such devices on traps where oil is found, soon become so fouled that they are next to useless as indicators, unless cleaned frequently. If the blowoff is connected to the sewer, it also should have a trap, for it is quite possible that the valve on this pipe will be left open occasionally when the equipment is not in use or the trap is open for cleaning or repairs. Some men will say this is a needless precaution, but, in my opinion, all sewer connections should be provided with traps.

Toronto, Canada. JAMES E. NOBLE.

Leak in Boiler Joint Located by Compressed Air

SOON AFTER one of our boilers had been installed and put into service, a leak developed in the butt strap joint of one of the steam drums. The insulating material was stripped off the drum where the leak was and its location marked. The next time the boiler was out of service, only the part where the leak appeared was well calked, since it was deemed inadvisable to attempt to calk the full length of the seam with the boiler under pressure. The



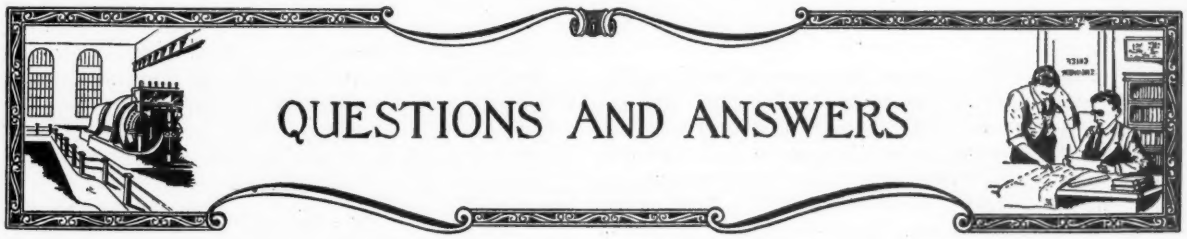
DOUBLE BUTT STRAP JOINT PROVIDED WITH AIR PIPE CONNECTION FOR TESTING LEAK

boiler was again put into service and it was found that the leak had not been stopped, it having only moved along beyond the part that had been calked.

The futility of trying to stop the leak by calking the outside of the boiler was realized and it was decided to locate the leak on the inside of the boiler and stop it there when the boiler was out of service. To do this a hole was drilled through the outer butt strap near the point of leak and located so as to enter the plate joint part way, as shown in the accompanying sketch. The hole was tapped for a ¼-in. pipe connection and air at about 100-lb. gage pressure was introduced into the plate joint along which it was free to travel from end to end and escape at the point of leak.

The leak inside the drum was discovered by applying soapy water to the seams and rivet heads, the leaking air bubbling through the soapy water. Calking the seam at this point ended the trouble.

Long Beach, Calif. E. J. JORDAN.



Why Is Superheated Steam Used?

WHY IS superheated steam used for prime movers?

A. A. W.

A. Prime movers, whether reciprocating engines or turbines, depend for their motive power upon the pressure and volume of the steam so that the more nearly the steam becomes a perfect gas, the better it does its work. Also the less moisture present the greater is the amount of work that can be done.

Theoretical gain due to the use of superheat is comparatively small. Considering the additional expense of equipment and maintenance of superheating apparatus, the ultimate gain would appear to be a negative quantity. Practically, however, the heat economy of the piston engine is greatly increased by superheat. This apparent anomaly is due to the fact that the theoretical engine is assumed to operate in a non-conducting cycle and that no condensation takes place except in doing work, whereas in the actual mechanism the cylinder is far from being non-conducting and considerable initial condensation takes place. The reduction of cylinder condensation by the use of superheated steam is the principal reason for the marked gain in economy of the actual engine. The greater the cylinder condensation, the larger is the saving possible. As a rough approximation, the steam consumption is reduced about 1 per cent for every 10 deg. increase in superheat, but the actual value depends upon the type and size of engine and the initial condition of the steam.

In American practice, superheat corresponding to a total steam temperature of 600 to 650 deg. F. appears to be the limit of economy, but in Europe temperatures as high as 850 deg. F. have been employed with apparent ultimate economy.

The effect of superheat upon the efficiency of steam turbines is more complicated as the steam flows continuously in the same direction and no initial condensation and re-evaporation occurs. The actual economy due to superheat is invariably greater than it is possible to figure theoretically from the data available.

Saving in steam due to the increase of the steam volume is of importance, but the large increase in efficiency of turbines caused by superheated steam is due to the fact that the absence of water in the steam decreases the frictional losses due to the passage of the steam through nozzles and blades. With superheated steam this friction is reduced because of the absence of moisture in the steam, particularly at the high velocities.

Windage loss or friction between the rotor and the enveloping vapor is also reduced by using superheated steam because of its lower density and the absence of moisture.

In addition to the economy which superheat shows in turbine performance, namely, a decrease in water rate of 1 per cent for each 12 deg. of superheat and a decrease in fuel of 1 per cent for each 20 deg. of superheat, the rapid erosion of turbine blades from moisture in steam is a factor that has forced the general adoption of superheated steam in turbines. Worn blading increases upkeep and reduces efficiency at a serious rate.

Cards Show Need of Increased Pressure

RELATIVE TO the article "How May Cards Be Improved?" by H. K. S., page 864, August 15 issue, I offer the following:

In the first place, from the standpoint of economy, all the diagrams show the engine is overloaded; however, some improvement may be made, I believe. With the exception of the exhaust valves opening too late, the other valve

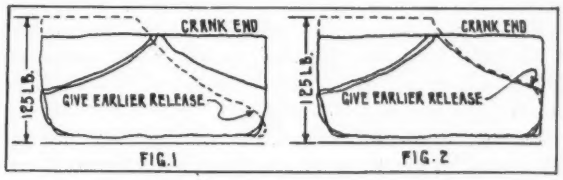


FIG. 1. INCREASING BOILER PRESSURE GIVES EARLIER CUT-OFF FOR SAME LOAD

FIG. 2. WITH SAME CUT-OFF, INCREASED PRESSURE GIVES GREATER POWER

events are good, as shown by the even and regular outlines of the diagrams, so I would suggest that an earlier opening and possibly an earlier closing be given both exhaust valves. This can be done by resetting the eccentric —giving it more angle of advance—and by minor adjustment with the "right and left" rod which connects the valve arm to the wristplate.

Next, I would suggest that the boiler pressure be increased to 125 lb., if that is both allowable and convenient. Possibly some increase, even as little as 5 lb., may be made to advantage. As shown in Fig. 1, by increasing the boiler pressure an earlier cutoff will be obtained for the same load that the engine is carrying at present, or, as shown by Fig. 2, with the same cutoff as at present a greater load can be carried with the same volume of steam entering the cylinder and with little increase in the weight of steam per stroke of the piston.

This is shown by the dotted lines drawn in the accompanying diagrams which are my solutions to Fig. 4 of the original article. In either case, a slight gain in economy will be effected, and of course, even a small gain is helpful and should be encouraged.

If it is not possible to increase the boiler pressure for any reason whatever, he still may make an improvement by changing the exhaust valves as before mentioned. Then there remains but one thing more that may be done, that is to increase the speed of the engine by a few revolutions, if that is both allowable and practicable. The speed at present is stated as 32 r.p.m., which seems low. Probably there is a reason for it. But in any event, he may be

able to increase it a few revolutions by weighting the governor.

Of course, it may be said that an overloaded engine is more economical than an underloaded engine, and that is true; but there is a limit beyond which we may not go successfully. According to his diagrams he is at the limit now, yet he requires more power and better economy. I trust that the foregoing may prove helpful to him, as far as his engine is concerned. How about the economy of his boiler, shafting and other power equipment?

Brooklyn, N. Y. CHARLES J. MASON.

Restricted Steam Supply Cause of Pressure Drop

IN ANSWER to the question by Tom Jones in the September 1 issue, page 918, I wish to state that simply analyzing the diagrams as presented, without taking into consideration any other possible influencing factors, the following conclusions may be reached:

First, the sloping steam lines of the cylinder diagrams seem to show that the piston of the engine is "running away from the steam," hence the gradual drop in pressure. This may be due to the steam ports being either too small in design, or not opened wide enough to permit a sufficient quantity of steam to follow the piston and maintain the pressure up to the point of cutoff. If the steam ports are large enough and if the steam valves open wide enough, then the fault may lie in the steam pipe not being large enough to supply steam without drop in pressure.

Next, the variation in pressure shown in the steam chest diagrams looks as if the steam pipe is too small to supply the required quantity of steam to maintain an even pressure up to the point of cutoff in the engine cylinder.

Irregularities in both sets of diagrams, however, coincide so that between the two possibilities mentioned, it would be difficult to determine which one is the cause of the drop in pressure. Perhaps it may be caused by both steam pipe and steam ports being too small. As before stated, the foregoing considers only the outlines of the diagrams.

But we know that condensation of the steam is taking place in steam lines and steam cylinders, unless the steam is highly superheated in the first place, and this condensation is considerably augmented by long pipes, with many bends or turns, possible uncovered piping, or uncovered fittings and flanges and these factors always cause a drop in pressure. As the engine is overloaded, possibly the steam is leaving the boiler with a certain moisture content, intensified by the factors previously mentioned.

Again, the indicator itself, and the connecting piping and fittings may be contributing to the condensation already in the engine cylinder, thus further intensifying the trouble.

As a matter of fact, when all things are taken into consideration, the diagrams as a whole show a good condition of affairs in that engine. The difference in pressure is really not worth worrying over. Most of all—if not all—engines show such differences, and many show a much worse condition of affairs, as many of us know.

With regard to the overloaded condition, why not increase the boiler pressure a few pounds, if it is permissible to do so and if it is convenient to all departments of the plant. An increase of 5 or 10 lb. in boiler pressure, as well as relieving the overload condition, may perhaps reduce the loss in pressure complained of by your correspondent.

Brooklyn, N. Y. CHARLES J. MASON.

IN REPLY to Tom Jones's inquiry, page 918, Sept. 1 issue, I would say the steam drop during admission is due to steam leaking past the piston or the valves. The compression lines of his indicator cards indicate such leaks, since, if the piston and valves are tight, the compression line generally curves in one direction until it meets the admission line. This curve of the compression line changes as the piston nears the end of the stroke, sometimes becoming so pronounced as to form a hook.

With the leaks as shown on his indicator cards, I am at a loss to understand how this engine can be overloaded as stated.

Chicago, Ill. E. S. KIMMEL.

What Size Economizer Is Needed?

OUR MUFFLE furnace burns 66 gal. of 24—26 deg. Bé. oil per hour. Heat value of the oil is 19,200 B.t.u. and excess air is 25 per cent. The temperature of the waste gases is 1400 deg. F. Draft is forced. If these gases were sent through an efficient heater filled with water under pressure, how many heat units per hour would be recovered and how much heating surface would be needed? Since forced draft is to be used, the gases could leave the heater at about 300 deg. F. J. M. S.

A. Such a heater is really an economizer and the heat transfer may be calculated in the usual way. But since you neglected to give an ultimate analysis of the fuel, we must, of course, assume such an analysis in order to determine the number of pounds of flue gas when operating with 25 per cent excess air. We therefore assume 86 per cent carbon, 13 per cent hydrogen and 1 per cent oxygen. We then find the number of pounds of air required per pound of fuel by the following formula:

$11.52\ C + 34.56\ (H—0/8) =$ lb. air required per lb. of fuel.

If the figures in the ultimate analysis are substituted, we then arrive at 13.83 lb. of air required per lb. of fuel, with no excess. With 25 per cent excess, we have $13.83 \times 1.25 = 17.29$ lb. of air per lb. of fuel.

Then for each pound of fuel we have: $17.29 + 1.00 = 18.29$ lb. of gas per lb. of fuel.

An average of 24 deg. to 26 deg. Bé. oil would be 25 deg. Bé. Oil of this gravity weighs 7.533 lb. per gal. $7.533 \times 66 = 497.18$ lb. per hr.

Since the gravity of the oil has not been stated exactly, we can, for convenience, assume a fuel consumption of 500 lb. per hr. Then, if we have 18.29 lb. of gas per lb. of fuel, we will have $18.29 \times 500 = 9145$ lb. of gas per hr.

If the gas enters the economizer at 1400 deg. F. and leaves at 300 deg. F., then the temperature drop equals: $1400 — 300 = 1100$ deg. F.

Since the specific heat of flue gas = 0.24 B.t.u., then the number of B.t.u. heat recovery is: $9145 \times 0.24 \times 1100 = 2{,}414{,}280$ B.t.u.

The amount of heating surface may be calculated from the following formula:

$$S = \frac{WC\,(t_2 - t_1)}{Ud}$$

where S = total heating surface of economizer in sq. ft.; U = mean coefficient of heat transmission B.t.u. per hr. per sq. ft. per deg. mean temperature difference = 4.25 B.t.u. for a cast-iron economizer; d = mean temperature difference between gas and water. For practical purposes the arithmetical mean temperature difference may be used, in which case $d = \frac{(t_1 + t_2)}{2} - \frac{(t + t_0)}{2}$. W = weight of flue gas per hr. C = mean specific heat of flue gas. t_1 = final flue gas temperature. t_2 = initial flue gas temperature. t = final temperature of the water to be heated. t_0 = initial temperature of the water.

In your problem you did not state either the initial or final temperature of the water so we must assume these values. We will assume that the water enters at 70 deg. and leaves at 225 deg. Then, according to the above equation: $d = \frac{(300 + 1400)}{2} - \frac{(225 + 70)}{2} = 702$ deg. F., mean temperature difference.

Then, substituting all the values in the equation for determining the heating surface, we have:

$$s = \frac{9145 \times 0.24\,(1400 - 300)}{4.25 \times 702}$$

This gives 809 sq. ft. of heating surface required.

When D. C. Produces A. C.

IN THE issue of July 15, I noticed your answer to the question, "When D.C. produces A.C." I can't understand your explanation of the change in direction of current on the scondary side and would greatly appreciate your explaining the matter more fully. L. P.

A. This can be illustrated in a simple manner as follows: Suppose a straight conductor is moved between the poles of a magnet as shown in Fig. 1, the direction of flux between the poles of this magnet being downward and the direction of motion of the conductor being from right to left.

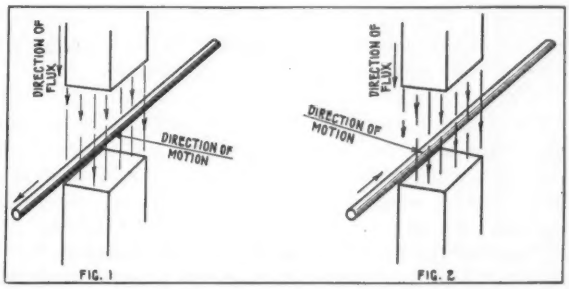
Under these conditions, due to the cutting of the lines of force, we can find the direction of the current induced in the conductor by the right hand rule. This rule states that if the thumb, forefinger and middle finger of the right hand are all held at right angles to each other, and if the thumb points in the direction of motion of the conductor, the forefinger in the direction of the flux, then the direction of current induced in the conductor will be indicated by the middle finger. According to this rule we find that the direction of current induced in the wire shown in Fig. 1 is as indicated by the arrow.

Now, suppose that we reverse the direction of motion of the conductor as shown in Fig. 2. Here conditions remain the same as in Fig. 1, except the direction of motion.

According to the right hand rule, we find that the induced current in the conductor has also reversed in direction. It is thus seen that by moving a conductor back and forth between the poles of a magnet, the direction of flux remaining the same, the current induced in the conductor will be reversed with each reversal of the motion. In other words, there will be induced in the conductor an alternating current. It is assumed of course that the ends of the conductor are joined so as to form a closed circuit.

Now, it must be evident that, if instead of moving the conductor back and forth between the poles of the magnet, the same result could be attained by leaving the conductor stationary and moving the magnet itself. In other words, the magnetic field would be moved through the conductor instead of the conductor through the magnetic field. In this case, also, an alternating current would be set up in the conductor.

In the illustration shown with the article appearing in the July 15 issue, it will be noted that a magnetic field exists due to the current flowing in the primary conductor. The direction of this field around the wire is dependent entirely upon the direction of the current in the conductor. If the direction of current is as shown, the direction of the field will be clockwise. If the direction of current reverses, the direction of the field will be counterclockwise. By impressing a pulsating direct current on the primary conductor, the direction of the field will always be the same, but due to the varying intensity of the current, the field strength will also vary in intensity. In other words, as the current builds up, the field becomes



RIGHT HAND RULE SHOWS DIRECTION OF INDUCED CURRENT REVERSES WITH REVERSAL OF DIRECTION OF MOTION

stronger and spreads out from the wire. As the current decreases in value the magnetic field collapses.

This spreading out and collapsing of the magnetic field produces the same effect with respect to the secondary conductor that we have in the foregoing illustration of the conductor between the poles of the magnet. As the magnetic field sweeps in one direction, the current induced in the secondary is in a certain direction, and as it sweeps in the other direction, the current reverses. In this way an alternating current is induced in the secondary from a pulsating current flowing in the primary.

From this illustration it must also be evident that it is impossible to produce a pulsating current in the secondary of the transformer by any kind of current flowing in the primary. The current flowing in the secondary will always be alternating, regardless of whether the current in the primary is alternating or pulsating direct.

STEAM TURBO-GENERATORS should never be allowed to motor or be rotated from the generator end at a high speed for any length of time without steam being present around and through the blading, as the proper clearance between blading and nozzles is maintained only at steam temperature.

EDITORIAL COMMENT

To Whom Is the Engineer Responsible?

Quite a number of our states have engineers' license laws in effect. To secure a license which will permit a man to hold a position as engineer, he must present evidence to the examiner that he not only has had sufficient practical experience but possesses a knowledge of power equipment which fits him for the work and responsibility in the class for which he is seeking a license.

Legally, about the only reason a state has for passing laws licensing engineers is to protect the public against injury due to an incompetent engineer.

In the present day order of things, the power plant engineer is usually an employe who receives his orders from the owner and, if the public is to be protected, the engineer must do so, frequently at the risk of losing his position. Employers are not always keen for being told by their engineers that certain improvements must be made. In too many cases they are ready to use their power of authority to demand that an engineer, contrary to his better judgment; operate machinery which is really unsafe.

When an engineer encounters such a situation, his duty to his employer ceases for, in case of accident, he is held responsible to the public and his license may be revoked. This was demonstrated recently when, as the result of the disaster which wrecked the steamer "Mackinac," the chief engineer's license was taken away from him by the examining board of the United States Steamboat Inspection Service who found him guilty of operating a boiler which he knew to be in a dangerous condition.

As the engineers' license laws have worked out, the licensed engineer has a double responsibility, first to the public for safety and second to his employer for economy.

Executives Must Not Always Avoid Details

It has become almost a truism, says a prominent writer of business articles, that successful executives are those who turn details over to others. This alleged fact, he continues, has been repeated so often by business writers, usually without comment, that there is danger of all of us regarding ourselves as failures unless we banish detail completely. But details are nothing but facts, and no successful executive, however he may delegate responsibility, can avoid the necessity of digging down into the details, or facts, when the occasion arises.

Engineering work of any kind is based primarily on facts. We feel that the average power plant executive or, in fact, the engineer executive in other branches of industry, is not in as much danger of forgetting the importance of details as the executive who has not had technical training. The important thing to be remembered is that the executive must retain, not the habit of indiscriminately attending to detail work, but the capacity to do so when the occasion is important enough to warrant it.

On the other hand, the executive who attempts to keep his mind full of the details of the work of his subordinates, details of record-keeping, unnecessary letter-writing, insistence on petty points of discipline and like matters, is going to the other extreme and is winding himself up in a mass of red tape that will destroy his capacity for oversight just as surely as will neglect of details. If he nags his subordinates about the details of their work, making little distinction between important and unimportant matters, he becomes known as a "fusser," an "old woman." If he delegates all responsibility to others, without checking up occasionally, he has no facts on which to base his decisions in regard to the larger problems and policies of the plant or of the company. To steer a middle course between these two methods is often difficult but the power plant executive must learn to do it.

To be able to dominate the red tape with a firm hand when necessary and to possess the capacity to dig through the mass of details for the underlying facts when that is required—these are the fundamental characteristics of the successful executive. Most engineers know that such a man is a far different figure from the executive portrayed by the average newspaper or business writer, who, if he ever could attain one of these supervisory positions about which he writes so fluently, would be quickly disillusioned.

Wanted, a Hydrogen-Tight Shaft Packing

Before the days of airplanes and motor-boats which put the Twentieth Century Limited to shame, man traveled slowly and gave little thought to the power required to overcome resistance to his motion offered by the air. Today, when he travels at speeds anywhere between 60 and 250 miles per hour, the power necessary to overcome air resistance becomes an important factor and must be taken into account in the design of his vehicles whatever their type. In the design of aircraft, much investigation has taken place with a view of reducing the wind resistance and turbulence set up by the various parts. The same is true in marine work. Ships are constructed so that their passage through the water may be effected with a minimum expenditure of energy.

Similarly, in the design of modern high-speed electrical machinery, the windage losses must be carefully considered. The electrical designer, however, has the advantage over the aircraft or ship designer in that he can not only modify the shape of the machine parts but can also change the medium in which the machine operates. This brings us to the question of electrical machine ventilation.

As long as electric generating equipment was of small capacity, problems of ventilation were simple. There was a time when such equipment presented sufficient radiating surface to the surrounding air to dissipate the heat losses in the machine without resorting to artificial cooling but, with the small high speed, high capacity generators used

today, the problem has become complex and the closed ventilating system has come into common use.

Use of the closed ventilating system has two distinct advantages in that the accumulation of dust on the windings is practically eliminated and internal fires in the windings can be easily extinguished by introducing an inert gas into the system. Carbon dioxide has been used in this connection with good results, the introduction of 25 per cent by volume of carbon dioxide gas into the ventilating system being found to extinguish the flames.

Need of providing a separate medium for fire fighting purposes led to the idea of using the inert gas, carbon dioxide or whatever other gas might be used, as the cooling medium itself. It was found upon investigation that some of the inert gases available have characteristics much better than those of air as a cooling medium in high-speed machines.

A large number of gases have been considered and, strange to say, hydrogen has been found to have the most advantageous properties in spite of the fact that it is highly explosive. The latter property, it would seem, would preclude its use for fire extinguishing purposes but it has been shown that, if all air can be excluded, hydrogen is an excellent medium in this respect. Compared with air it has many advantages. First, the windage losses are greatly reduced due to the much lower specific gravity of hydrogen and its high thermal capacity. Second, the temperature drop required to transmit heat through various parts of the machine is reduced. Third, if air can be excluded, hydrogen is a good fire extinguishing medium. Fourth, the temperature drop required to transmit heat from the hot surfaces of the machine to the hydrogen and from the hydrogen to the coolers is low, causing the hydrogen to return to the machine at a low temperature.

These advantages are too important not to be realized in practice and should warrant considerable effort being expended in overcoming the one disadvantage of hydrogen, that of explosion danger. Results of tests on generators filled with hydrogen, show that it is possible to carry 30 per cent more load on a machine with the same temperature rise, when hydrogen is used for cooling in place of air.

The principal difficulty encountered in using hydrogen is in the design of a suitable shaft packing. It would be comparatively simple to make a rotating machine hydrogen-tight, if suitable shaft packing could be developed.

Here, in our estimation, is a real opportunity for an engineer with an inventive mind. It is true, that this problem naturally belongs to the manufacturers, but among the operating engineers there are no doubt a number of men who have ideas on the subject which, if properly developed, would aid in successfully solving the problem. At any rate it is well worth while thinking about.

Fairness Requisite for Continued Success

When two business concerns have dealings, they expect to give as well as get fair treatment. The surest way to break off business relations is to be unfair and the individual company or corporation which makes the greatest success is the one whose business dealings are the fairest to all parties. In the case of public utilities, however, conditions are somewhat different in that a virtual monopoly of service exists, so that the customer must either take it from one company or do without. This condition would appear to give an undesirable opportunity for unfairness on the part of the utility company, but experience has shown that, where the spirit of unfairness exists, the pendulum of business success and failure is started swinging as is well expressed in a recent decision handed down by the Idaho Public Utilities Commission which follows:

"A public utility which imposes an unfair burden of rates on its consumers, or otherwise treats them unfairly, may gain a somewhat increased revenue for a time but inevitably will be forced to meet hampering resentment and hostility which will cause higher costs, a reduced number of customers, a lessened amount of use by restrained customers and these will certainly result in reducing the value of the utility's investment, even if the loss of much of it is avoided.

"On the other hand, the public can, for a time, force a level of rates below the point of fairness. By so doing, it temporarily reduces the amount paid for service but a rapid reduction of quality and quantity of service promptly results.

"No one, whether it be an individual or a public utility, can for very long obtain more than is fairly paid for. More than this there would be a prompt check of service expansion, not only by the utility affected but by all others where further investment is needed for public service.

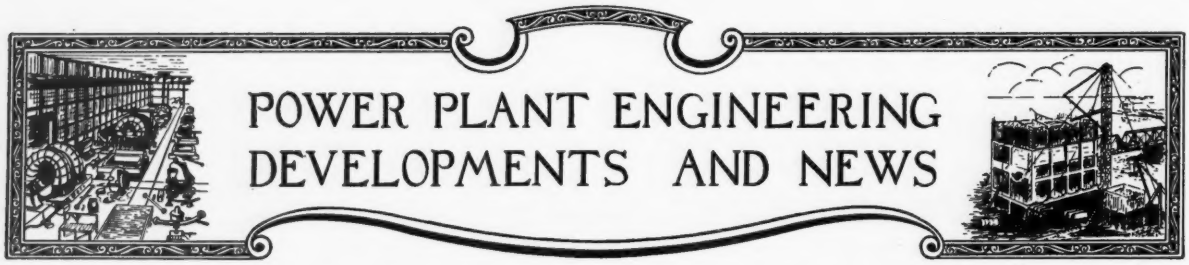
"Investors do not go where unfairness is waiting. This would seriously affect and retard the development of the state, as one of the most important elements in state progress is ample and satisfactory utility service and the ready extension of it as it may be needed. In either case the state suffers."

New Power Plants Aid Community Development

Just as in the pioneering days of our country, settlements were made along the navigable streams and beside the rivers and creeks where power could be generated for the sawing of logs and grinding of wheat into flour, so today industry builds up around new power plants that are advantageously located to furnish power for industrial and domestic uses.

Every power plant that is put into operation is a source of opportunity rarely appreciated by the people of the community. The industry, employment wages, production and purchasing power of a community served by a new power plant are all advantageously affected when the plant is put into operation. Estimates as to the financial value of such a plant to the community have recently been made and carefully tabulated by the New York State Committee on Public Utility Information.

In its estimates the committee placed the cost of a 10,000-hp. hydro-electric generating station at $2,500,000, the approximate cost of a steam plant of the same capacity being considerably less. Such a plant would furnish power sufficient for operating factories and equipment worth, on an average, $16,000,000. The cost of labor for operating this plant is placed at $20,000 a year, 12 men being required. The factories supplied with power would furnish employment for 3750 persons earning $5,500,000 annually. In their homes, the families of these workers would support storekeepers and others who supply them with things they need, the whole forming a community of 20,000 people and, as a result of the building of this 10,000-hp. plant, the purchasing power of the community would increase many million dollars a year.



N. A. S. E. Holds 43rd Convention at St. Paul

ASSOCIATION PLANS EXTENSIVE EDUCATIONAL WORK, VISITS N. E. A. EXHIBIT AND HEARS TECHNICAL PAPERS AT 5-DAY MEETING

AT THE 43rd annual convention of the National Association of Stationary Engineers held in St. Paul, Minn., from Aug. 31 to Sept. 4, several interesting technical papers were presented, a splendid exhibition of engineering equipment was held by the National Exhibitors' Association, and much business of importance to the engineers was transacted at the regular business sessions. Delegates attended to the number of 364, other visiting N. A. S. E. members with their families and friends bringing the total attendance up to about 1000.

REPRESENTATIVES OF N. A. S. E. AND N. E. A. AT ST. PAUL

Considerable time was given by the delegates to the discussion of a national educational program, involving an expenditure of about $11,000 and similar to the merit system already in use in the state of Michigan. This plan was finally adopted by the convention.

On the exhibition floor of the municipal Auditorium, 152 exhibitors displayed a varied collection of power plant equipment which proved of great interest to the engineers, as well as to the general public. Throughout the convention, entertainments of pleasing character were provided for the N. A. S. E. and its Ladies Auxiliary.

On Monday, Aug. 31, registration of officials, delegates, exhibitors and visitors took place at the Auditorium. The exposition opened officially on the evening of that day and the N. A. S. E. held a reception and informal dance in the Hotel St. Paul. On Tuesday morning, after a parade from the Hotel St. Paul to the Auditorium, the convention opened officially with an address of welcome for the state of Minnesota by J. H. Hay, deputy commissioner of the Department of Agriculture of Minnesota, to which National President Dudley G. Kimball responded for the N. A. S. E. The City of St. Paul, through Mayor Arthur Nelson, welcomed the delegates to the city, complimenting the organization and the Ladies Auxiliary for their great work. National Vice-President Garrett Burgess, in responding to Mayor Nelson, called attention to the great problems facing the organization. The next speaker was President Asa Briggs of the St. Paul Association of Civic and Public Affairs, response being made by Past National President Holbrook. The final address of the morning was made by L. R. Ferguson, Commissioner of Education.

On Tuesday afternoon, Sept. 1, the first business session of the convention was called to order in the Auditorium by National President Dudley G. Kimball. Reports were presented by National Secretary Raven, National Treasurer Samuel B. Forse, National President Dudley G. Kimball, and National Vice-President Garrett Burgess.

President Kimball, in his report, recommended that the membership committee be abolished, advocated the publication of the 1924 and 1925 questions and answers in book form and stated that if 30,000 members are en-

rolled in 1926, the difficult question of advertising for the official magazine, raised during the past year, will be automatically eliminated by the increased circulation. He also expressed his adverse opinion on the use of the association's name in connection with power shows in various parts of the country.

National Vice-President Burgess enlarged on the importance of the work of the state deputies. He made a plea for more publicity and for closer contact with employers and closed with the report that, during the year, sixteen new associations have been formed, with a net gain in total membership of 273.

Frederick L. Ray then read the report of the national educational committee. In this report, the committee reviewed the work done during the past year in conducting a question and answer contest, in awarding prizes for papers published in the National Engineer and in encouraging the use of the lectures and lantern slides by various local associations. The committee also commented on the special agreement with the International Correspondence Schools and on the establishment of an information service department, which had published valuable data in the official magazine, in loose-leaf form, and had also issued, in book form, the prize questions and answers of 1923-24.

The committee felt that the question and answer contest had been a failure and that lack of interest in the correspondence courses did not warrant continuance of the plan. It was recommended, however, that the cash prizes for best engineering papers be continued, together with the lecture and lantern slide service and that questions and answers for 1924-25 be published in book form. Attention was called to the merit system, advocated by the committee and submitted as Exhibits A and B of the report.

This report proposed that the N. A. S. E. undertake to carry out on a national scale the merit system of educational work in engineering subjects, along the lines worked out and tried in Michigan for 2 yr. This work involves the conducting by the Association of various courses in mechanical and electrical engineering using the question and answer method. The questions are to be prepared by suitable committees, utilizing all the engineering resources of the Association. An examining board of members of the Association will issue certificates of merit to all who pass the required examinations. Courses in mathematics will be given and in applying for any of the courses other than practical, a candidate must pass the mathematical examination with a rating of 80 per cent.

It was carefully pointed out by the committee that this merit system is not intended in any way to interfere with the usual state examinations for licenses, but to aid the candidates in preparing to get licenses. The engineers' license laws, it is stated, are primarily safety measures.

Information Service Department Advocated

In connection with this work, the Educational Committee also recommended the establishment of an information service department, to compile and distribute to members engineering data of all kinds. By issuing these data in loose-leaf form, similar to the data sheets published in the National Engineer, they can be kept up to date.

Immediately after the close of this business session, the first technical paper was presented by F. L. Hansen,

REPRESENTATIVES OF N. A. S. E. AND N. E. A. AT ST. PAUL

of the Ideal Electric & Mfg. Co., Mansfield, Ohio, on "The Evolution of the Synchronous Machine from the Early Days to the Present Time." In this paper, which had been prepared by Theodore Schou, but was delivered in his absence by Mr. Hansen, the development of a.c. machines was reviewed, beginning with the work of Pixii and Faraday. The polyphase motor of Tesla was described. as well as the monocyclic generator of Steinmetz, and the paper concluded with a detailed discussion of the modern flywheel type of synchronous motor.

The Life and Accident Insurance Department of the N. A. S. E. held its annual meeting on Tuesday afternoon. It was reported that 73 claims have been paid during the year and 96 new members enrolled in the department. James D. Taylor was unanimously re-elected to the position of secretary-treasurer of this department.

Visiting ladies of the association were entertained on Tuesday evening by Capitol Auxiliary No. 2 of St. Paul. At the same time in the Auditorium, a public educational

session was held, at which a paper on "The Use of Man's Most Personal Servant" was read by its author, C. E. Skinner, assistant director of engineering of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The speaker outlined the many functions electricity performs and emphasized the dependence of modern civilization on it. Preceding and following Mr. Skinner's talk, motion pictures were shown; two reels entitled "White Coal" showed outstanding hydroelectric developments and "An Electrified Travelogue" showed the part played by electric power in transportation.

After a short business session on Wednesday morning, at which reports of the membership extension committee, ways and means committee, board of arbitration and board of trustees were presented, a technical paper was read by Wm. G. Schneider, research engineer of the Copper & Brass Research Association on "The Uses of Copper and Brass in the Power Plant."

Outing and Entertainment Arouse Interest

Wednesday afternoon and evening were given over by both engineers and exhibitors to a recreational program.

REPRESENTATIVES OF N. A. S. E. AND N. E. A. AT ST. PAUL

In the afternoon an outing was held at Harriett Island, the feature of which was the baseball game between engineers and exhibitors, which the latter won by a score of 16 to 2. In the evening, an entertainment, arranged by the exhibitors' entertainment committee, Paul T. Payne, chairman, was given in the Auditorium, by the following artists: George Ogden, Singer; Joe McKenna, Songs and Stories; Bobby Jones, Tenor; Twin City Blue Jackets—Ladies Eight Piece Orchestra; Monsieur Pietro; Coella Dare—Petite Comedienne; Earl Patwell—Comedian; Elsy Ohlsen—Accordianist; Ed. Haagensen—Monologist; Grace Aldrich—Soprano; Loury Quartette.

Discussion of the merit system as outlined in the report of the educational committee was the outstanding feature of the Thursday business sessions. Many delegates gave their views, some objecting to the Association carrying on the actual educational work, although most of the members were agreed as to the desirability of supervising the work. Some objection was also made to the requirement of one year's membership and five years' experience before being permitted to apply for the courses. The majority of the delegates, however, felt that details of arrangement could be left safely to the educational committee, that there was little conflict with state license laws, which were primarily safety measures, and that the program, as laid out by the committee, offered a definite plan to interest and hold the younger engineers that the organization must have for its continued success. After a full discussion of all phases of the plan in both morning and afternoon sessions, the merit system was adopted by a vote of 165 for, to 130 against. The motion to conduct the Information Service Department, as outlined by the committee, was also carried.

Engineers and Exhibitors Elect Officers

On Friday morning, the last session was held in the Auditorium. Reports of the auditing committee and others were heard. Flags were awarded to local associations for membership gains and the convention closed with election of officers.

The following officers were elected for the ensuing year: President, Garrett Burgess, of Detroit, Mich.; Vice-Pres., John Q. Adams, of Duluth, Minn.; Secretary, Fred W. Raven, of Chicago, re-elected for the 23rd term; Treasurer S. B. Forse, of Pittsburgh, re-elected for the 21st term; Trustee, Harold R. Hilton, of Los Angeles, re-elected; Conductor, Thomas H. Clark, of Worcester, Mass.; and doorkeeper, C. A. Dobson, of Knoxville, Tenn.

Atlantic City was selected for the next convention city.

The National Exhibitors' Association elected the following officers for the ensuing year: President, Chas. F. Green—Home Rubber Co.; Vice-President, Geo. R. Rowland—The Texas Co.; Treasurer, Jacob Eige—Fisher Governor Co. Executive Committee: Chairman, I. S. Pieters, Plibrico Jointless Firebrick Co.; Thomas F. Boyle, D. T. Williams Valve Co.; W. L. Rogers, Pioneer Rubber Co.; Geo. T. Ogden, The C. E. Squires Co.; Wm. T. Birch, Birch Mfg. Co. Frank N. Chapman, of the A. Leschen & Sons Rope Co., was re-appointed as Secretary.

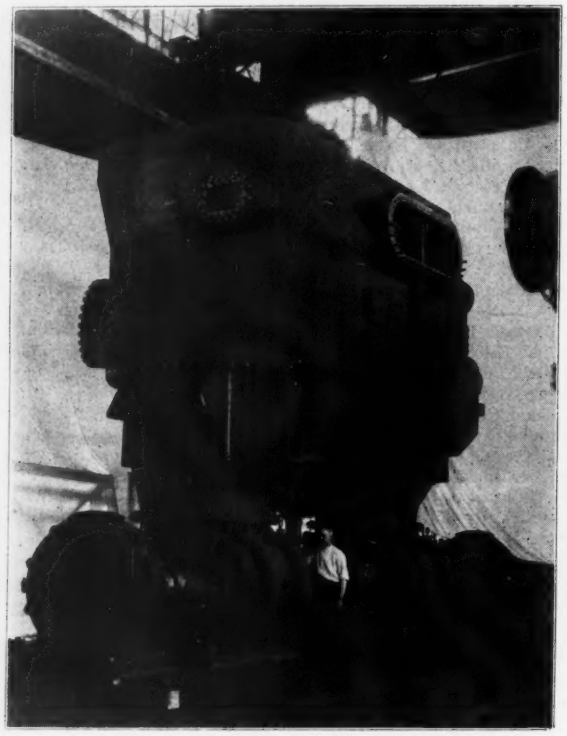
Exhibitors at N. A. S. E. Convention

Allis-Chalmers Mfg. Co. ..... Milwaukee, Wis.
American Supply Co ..... St. Paul, Minn.
Anchor Packing Co ..... Philadelphia, Pa.
V. D. Anderson Co ..... Minneapolis, Minn.
Armstrong Machine Works ..... Three Rivers, Mich.
Arrow Boiler Compound Co ..... St. Louis, Mo.
The Ashton Valve Co ..... E. Cambridge, Mass.
Atwood & Morrill Co ..... Salem, Mass.
Bailey Meter Co ..... Cleveland, Ohio
L. M. Bartlett Co ..... Minneapolis, Minn.
The Bayer Co ..... St. Louis, Mo.
Birch Mfg. Co ..... Chicago, Ill.
S. F. Bowser & Co., Inc ..... Fort Wayne, Ind.
Brooks Oil Co ..... Minneapolis, Minn.
Wm. Bros. Boiler & Mfg. Co ..... Minneapolis, Minn.
Stewart R. Browne Mfg. Co ..... St. Paul, Minn.
Bussman Mfg. Co ..... St. Louis, Mo.
Barco Mfg. Co ..... Chicago, Ill.
Budd Grate Co ..... Philadelphia, Pa.
Baker Valve Co ..... Minneapolis, Minn.
Carbon Engineering Co ..... Milwaukee, Wis.
A. W. Cash Co ..... Decatur, Ill.
Cass Mfg. Co ..... Chicago, Ill.
Chicago Faucet Co ..... Chicago, Ill.
Chicago Fuse Mfg. Co ..... Chicago, Ill.
Chicago Metallic Packing Co ..... Chicago, Ill.
Cities Service Oil Co ..... St. Paul, Minn.
Jas. Clark, Jr. Electric Co ..... Louisville, Ky.
Cokal Stoker Corp ..... Chicago, Ill.
Combustion Engineering Corp ..... New York, N. Y.
Commonwealth Electric Co ..... St. Paul, Minn.
Crandall Packing Co ..... Palmyra, N. Y.
Crane Co ..... Chicago, Ill.
Crane Packing Co ..... Chicago, Ill.
Chicago Chemical Co ..... Minneapolis, Minn.
Dearborn Chemical Co ..... Chicago, Ill.
M. H. Detrick Co ..... Chicago, Ill.
Detroit Stoker Co ..... Detroit, Mich.
Joseph Dixon Crucible Co ..... Jersey City, N. J.
Durametallic Corp ..... Kalamazoo, Mich.
Economy Fuse & Mfg. Co ..... Chicago, Ill.
Elliott Co ..... Jeanette, Pa.
Everlasting Valve Co ..... Jersey City, N. J.
Factory Sales Co ..... St. Paul, Minn.
The Falk Corp ..... Milwaukee, Wis.
The Fisher Governor Co ..... Marshalltown, Iowa
Flexible Steel Packing Co ..... Chicago, Ill.
J. B. Ford Co ..... Wyandotte, Mich.
France Packing Co ..... Philadelphia, Pa.
Fuel Economy Eng. Co ..... St. Paul, Minn.
The Frederick Iron & Steel Co ..... Frederick, Md.
Garlock Packing Co ..... Palmyra, N. Y.
Garratt-Callahan Co ..... Chicago, Ill.
Greene, Tweed & Co ..... New York, N. Y.
A. P. Green Fire Brick Co ..... Mexico, Mo.
J. W. Goar ..... St. Paul, Minn.
Globe Kneadable Metallic Packing Co ..... Brooklyn, N. Y.
Halverson Eng'g Co ..... Minneapolis, Minn.
Hawk-Eye Compound Co ..... Blue Island, Ill.
Healy Ruff Co ..... St. Paul, Minn.
Heat Sealing Kant-Burn Co ..... Chicago, Ill.
F. T. Hildred & Co ..... St. Paul, Minn.
Hoffman Specialty Co., Inc ..... Waterbury, Conn.
The Hollow Center Packing Co ..... Cleveland, Ohio
Home Rubber Co ..... Trenton, N. J.
Holley Mfg. Co ..... Minneapolis, Minn.
International Correspondence Schools ..... Scranton, Pa.
Jacks Mfg. Co ..... St. Paul, Minn.
Jenkins Bros ..... New York, N. Y.
Johns-Manville, Inc ..... Chicago, Ill.
Johns-Pratt Co ..... Hartford, Conn.
A. P. Jurgens Co ..... St. Paul, Minn.
Keasby & Mattison ..... Ambler, Pa.
Kenny Boiler & Mfg. Co ..... Minneapolis, Minn.
Kent Eng'g Co ..... Minneapolis, Minn.
The Keystone Lubricating Co ..... Philadelphia, Pa.
King Refractories Co., Inc ..... Buffalo, N. Y.
Gust Lagerquist ..... Minneapolis, Minn.
Lagonda Mfg. Co ..... Springfield, Ohio
A. Leschen & Sons Rope Co ..... St. Louis, Mo.
Liberty Mfg. Co ..... Pittsburgh, Pa.
Liptak Fire Brick Arch Co ..... Mexico, Mo.
The Lunkenheimer Co ..... Cincinnati, Ohio
Magie Brothers, Inc ..... Chicago, Ill.
Mason Regulator Co ..... Boston, Mass.
McCollough Mfg. Co ..... Minneapolis, Minn.
Midway Tent & Awning Co ..... St. Paul, Minn.
Morgan Gerrish Co ..... Minneapolis, Minn.
Mueller Boiler Compound Co ..... Minneapolis, Minn.
Multyplex Packing & Rubber Co ..... Toledo, Ohio
Minnesota Coal Co ..... St. Paul, Minn.
Motor Tool Specialty Co ..... Minneapolis, Minn.
National Air Filter Co ..... Chicago, Ill.
National Engineer ..... Chicago, Ill.
National Tube Co ..... Pittsburgh, Pa.
Northwestern Electrical Equipment Co ..... St. Paul, Minn.
W. S. Nott Co ..... Minneapolis, Minn.
North Western Fuel Co ..... St. Paul, Minn.
W. P. Nevine Co ..... Minneapolis, Minn.
Otis Elevator Co ..... New York, N. Y.
The Permutit Co ..... New York, N. Y.
The Perolin Co. of America ..... Chicago, Ill.
B. J. Peterson Co ..... Robbinsdale, Minn.
Pioneer Rubber Mills ..... San Francisco, Cal.
Plibrico Jointless Fire Brick Co ..... Chicago, Ill.
The Wm. Powell Co ..... Cincinnati, Ohio
Power ..... New York, N. Y.
Power Equipment Co ..... Minneapolis, Minn.
Power Plant Engineering ..... Chicago, Ill.
Albert C. Price Co ..... Minneapolis, Minn.
Price Electric Co ..... St. Paul, Minn.
Pittsburgh Coal Co ..... Minneapolis, Minn.
Page Water Tube Boiler Co ..... Chicago, Ill.
Quaker City Rubber Co ..... Philadelphia, Pa.
Quigley Furnace Spec. Co ..... New York, N. Y.
Reliance Gauge Column Co ..... Cleveland, Ohio
Richardson Scale Co ..... Passaic, N. J.
J. G. Robertson & Co ..... St. Paul, Minn.
John A. Roebling's Sons Co ..... Chicago, Ill.
Sim. D. Rollins & Co ..... Minneapolis, Minn.
Robinson Cary & Sands Co ..... St. Paul, Minn.
The Roto Co ..... Hartford, Conn.
C. Reiss Coal Co ..... St. Paul, Minn.
Scott Valve Mfg. Co ..... Detroit, Mich.
Scully Steel & Iron Co ..... Chicago, Ill.
Sinclair Refining Co ..... Chicago, Ill.
Sloan Valve Co ..... Chicago, Ill.
Southern Engineer ..... Atlanta, Ga.
The C. E. Squires Co ..... Cleveland, Ohio
St. Paul Machine Works ..... St. Paul, Minn.
St. Paul Electric Co ..... St. Paul, Minn.
Standard Oil Co. (Ind.) ..... Chicago, Ill.
Stewart Specialty Co ..... Minneapolis, Minn.
Sugar Beet Products Co ..... Saginaw, Mich.
The Superheater Co ..... New York, N. Y.
Smith Beal Fire Brick Co ..... Minneapolis, Minn.
Strong Scott Mfg. Co ..... Minneapolis, Minn.
The Texas Co ..... New York, N. Y.
Trane Co ..... La Crosse, Wis.
Tristate Products Co., Inc ..... Catlettsburg, Ky.
Uhl Co ..... Minneapolis, Minn.
United States Rubber Co ..... New York, N. Y.
Vacuum Oil Co ..... New York, N. Y.
Viscosity Oil Co ..... Chicago, Ill.
Warren Webster & Co ..... Camden, N. J.
Wayne Tank & Pump Co ..... Fort Wayne, Ind.
R. B. Whitacre & Co., Inc ..... St. Paul, Minn.
Wickes Boiler Co ..... Saginaw, Mich.
The D. T. Williams Valve Co ..... Cincinnati, Ohio
X-cel-all Master Lite Co ..... Monaca, Pa.
"X" Laboratories ..... New York, N. Y.

Largest Jet Condenser Undergoes Test

PROBABLY THE largest single jet condenser ever constructed is that recently manufactured by the Elliott Co. for the Narragansett Electric Lighting Co., Providence, R. I. This condenser, which serves a 35,000-kw. turbine, uses water at the rate of 36,000 g.p.m. Heretofore, it has not been considered feasible to construct such large condensers except in twin units whose steam inlets were connected to the turbine exhaust by means of a "Y" fitting. In other words, two condensers of 17,500-kw. capacity were used to make a 35,000-kw. combination. Both elements of the twin unit had to be cross connected for water, exhaust steam, and air.

The single condenser requires no cross connection pipes of any kind; the contour of the unit is such that it fits



STANDING 20 FT. HIGH AND EQUIPPED WITH TWO PUMPS, THIS JET CONDENSER SERVES A 35,000-KW. TURBINE

the space left by the foundation structure; the shape of the condenser body is approximately that of the turbine exhaust, so that the installation problem is reduced to its simplest form. By having two extraction pumps, all the advantages of a twin condenser are realized.

Design of the single condenser, however, presented difficulty in respect to the mixing chamber. The great concentration of water sprayed into a chamber of limited dimensions required other than the usual methods of insuring free contact of the steam with all of the circulating water. The usual types of spray nozzles are not suitable. Accordingly, there were developed, for use in large condensers, spray devices that form vertical sheets of water between which steam may pass to the lowermost bank of spray nozzles, so that a relatively complete contact is established between steam and all circulating water.

This large condenser has capacity to maintain a 29-in. vacuum when condensing 300,000 lb. of steam per hour, with water at about 56 deg. F. The circulating pumps require 225 hp. each and operate with an efficiency above 80 per cent. The distance between the turbine floor level and that on which the condenser rests is only 20 ft. 3 in.

On this unit, the ejector air pump handles almost 200 cu. ft. of free air per min. at 29-in. vacuum. To get some physical conception of what the ejector is capable of doing, it is of interest to note that a reciprocating pump of the usual volumetric efficiency to do the same work would have to have a 60-in. by 48-in. air cylinder operating at 50 r.p.m. On dry air tests, this ejector will maintain a 29-in. vacuum with a ¾-in. orifice admitting air to the suction pipe.

Continuous Slicing Breaks Up Clinkers

IN THE Advance stoker are embodied two fundamental principles of construction: reciprocating grate bars and horizontal air passages. The bars, each of which is pierced by horizontal openings, have inclined inner sur-

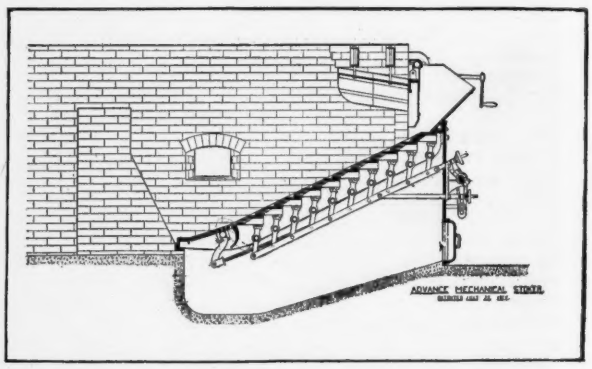


FIG. 1. SECTION OF THE ADVANCE STOKER SHOWS MECHANISM FOR RECIPROCATING BARS AND THE HORIZONTAL AIR SPACES

faces and are moved back and forth horizontally by rocker arms, driven through inclined links, from a rock shaft at the front of the boiler.

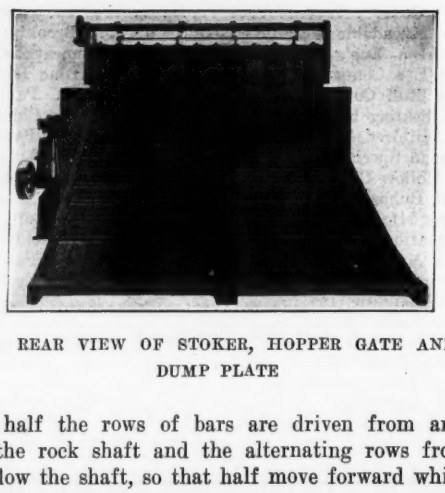


FIG. 2. REAR VIEW OF STOKER, HOPPER GATE AND ASH DUMP PLATE

As half the rows of bars are driven from an arm above the rock shaft and the alternating rows from an arm below the shaft, so that half move forward while the

other half move back, the fuel bed is continually sliced and moved forward. Ashes and clinker are thus broken up and cannot adhere to the grate. Also the fuel is moved slowly and steadily downward until it reaches the dump plate which is periodically operated to dump the ashes into the ash pit.

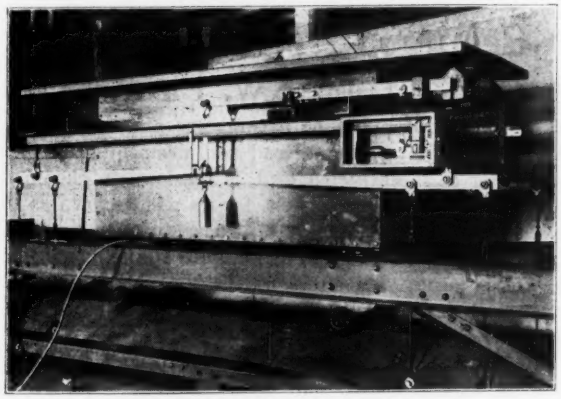
Speed of the fuel movement is controlled by adjustment at the rock shaft arms and thickness of the fuel bed by position of the tile-lined hopper gate at the upper end of the grate.

Horizontal air passages have been used to improve combustion and prevent sifting of fuel through the grate.

The Advance stoker is made by the Advance Machinery and Supply Co., Railroad Bldg., Denver, Colo.

Recording Coal and Ash Weights While Conveying

EXACT knowledge of the quantity of the coal, ash and other materials handled in the power plant is of importance in the production of power. To obtain correct weight on a conveyor scale the scale must be simple, automatic and strong, because in most cases it will have to operate with little attention and under extreme conditions



AUTOMATIC TARE DEDUCTION IS ACCOMPLISHED BY AN ADJUSTED CORRECTION FOR BELT TENSION

of dust. It is also advantageous that once adjusted it should not need readjusting unless the operating conditions are radically changed. A further desirable point is that the scale and the recorder can be installed wherever convenient, even separately, if so desired. These features have been incorporated in the Messiter Conveyor Scale, as manufactured by the Stearns Conveyor Co., Cleveland, O.

This scale can be applied to every form of conveyor in which part of the track can be freely suspended, thus including practically all forms of bucket, belt, apron, pan and other conveyors used in power house work. The scale itself is mounted over the conveyor framework at the most convenient point and supports a freely-suspended portion of the track; the loaded and return parts of the conveyor being independently suspended from opposite sides of the steelyard arms of the scale. The weight of the conveyor belt is thus completely neutralized and the tare is automatically deducted. Only the actual weight of the material conveyed is registered. The registering apparatus is operated electrically, thus affording the advantage that the recording instruments may be placed in any part of the plant which may be convenient, irrespective of the position of the actual scale itself.

Operation of the recording apparatus is based upon the laws of electrical power generation and consists essentially of the parts described as follows: A small electric generator is driven from the conveyor foot-shaft by means of a chain and sprocket wheel, or other form of positive drive. Since this generator is of the magneto or permanent magnet field type and since the current taken from it is so small that it has practically no effect on the voltage produced by the rotation of the armature, the voltage is in exact proportion to the revolutions per minute of the generator and therefore of the conveyor belt. The voltage naturally changes as the belt speed varies.

Current from this generator is modified by the action of a mercury dashpot and plunger. This plunger is actuated by the movements of the scale beams and varies the level of the mercury in the dashpot in such a manner as to cause resistances to be cut in or out to vary the current in proportion to the load carried. The product of the voltage and the current flowing in the circuit is thus directly proportional to the speed of the belt and the instantaneous weight, that is, to the total weight conveyed. This product is registered on an electric integrating wattmeter of suitable type calibrated to read in short, long or metric tons, barrels of a definite weight, or any other convenient weight unit.

Electrical system of recording may be extended to perform other functions besides the actual indicating. Should it be desirable to mix two or more kinds of fuel in exact proportions, the master meter can be made to operate a series of relay operated switches controlling the various conveyor motors so that the speeds of the belts or buckets is automatically varied to give the exact proportions required. The hoppers which feed the mechanical stokers may be kept full without attention by arranging a switch to start up the conveyor automatically and to feed any of the hoppers in the boiler room when required. Setting the weights which compensate for belt-tension and tare-deduction is easily and quickly accomplished and once correctly set there is no need for further adjustment, unless some change is made which would affect the weight of the tare or the belt-tension.

As has been indicated, this type of scale can be placed at any convenient point of the conveyor track, irrespective of whether the incline is upwards or downwards, or whether the scale comes at a point which is horizontal. In certain cases, however, it is necessary to depart somewhat from the method of installation already indicated. In the case, for instance, of a pivoted bucket conveyor handling coal and ashes to and from a battery of boilers it is necessary to use the two-scale or duplex system on account of the fact that the loaded and return buckets do not pass each other at any point of the conveyor-track and therefore cannot be balanced against each other on a single scale.

Conveyor Chains of Special Material

FARRELL'S Special Purpose Cast Steel, a material especially well adapted for use in conveyor chains as it has shown high tensile strength and great resistance to wear and abrasion in numerous tests, is now being used by Stephens-Adamson Mfg. Co. of Aurora, Ill., which firm has sole rights for chains made from this steel.

Chains of this material can be used for heavy conveyors and those handling abrasive material, without breaking down, yet the cost is less than for expensive alloy and manganese steels. Chains for elevators, for conveyors and for power transmission are now being put out in several types with necessary attachments for carrying elevator buckets and conveyor flights.

F. C. Houghton, New Director of A. S. H. V. E. Laboratory

ACCORDING TO an announcement of W. H. Driscoll, Chairman of the Committee on Research, the new Director of the Research Laboratory of the American Society of Heating and Ventilating Engineers, is F. C. Houghten. Mr. Houghten has already assumed his new duties in Pittsburgh.

Mr. Houghten returns to the scene of his former work where as first assistant to Dean Anderson, he conducted important investigations on a number of problems in heating and ventilation from 1920 to 1924. He has specialized in heating and ventilating research and because of his unusual training in this work he brings with him a wealth of experience.

In 1918 Mr. Houghten became connected with the U. S. Bureau of Mines carrying on research work during the war time period. He was put in charge of the physical laboratory as physicist. He later had charge of investigations of transmission of heat through boiler tubes, and an investigation conducted by the Bureau of Mines of heating and cooking devices used in the Army. He also had charge of research on combustion and heat transmission in large, low pressure heating boiler. In 1920 he was employed by Dean Allen then Director of the A.S.H.V.E. Research Laboratory, and in this connection he worked on heat transmission through building materials, co-operating in this work with Pennsylvania State College. Various other problems included in his investigations are the flow of steam in pipes, ozone and air conditioning including the effect of temperature, humidity and air motion on human beings.

Born in Troy, Mich., in 1888, he entered Olivet College at Olivet, Michigan in 1909 and graduated from there in 1913 with a degree of A. B. During the next two years he held teaching fellowship in Physics at the University of Washington. In 1915 he received there the Master of Science Degree in Physics and Mathematics. From 1915 to 1918 he taught science in the high schools at Ellensburg, and Hoquiam, Wash. He gave up teaching to do research in the Bureau of Mines at Pittsburgh.

Large Hydro Plant Planned for Louisville

STANDARD GAS and Electric Co. has announced that, with the issuance of a license by the Federal Power Commission to the Louisville Hydro-Electric Co.—one of Standard's units—work is to be started at once on the first modern hydro-electric power developments of the Ohio.

This plant, to be located at Louisville, Ky., will have an initial capacity of 108,000 hp. in eight 13,500-hp. units, with provision for an ultimate capacity of 135,000 hp.

The development of power at the falls of the Ohio is made possible by the construction by the Federal government of a dam nearly two miles long and 20 ft. high, which will extend obliquely across the river from the Indiana shore to Rock Island, and will form part of the government's plan to open the river to navigation.

Between Rock Island and the Kentucky shore a powerhouse, 507 ft. long, will be constructed under the supervision of the Byllesby Engineering and Management Corporation, at an estimated cost of $7,500,000. The cost of the dam to be built by the government will be $3,250,000, the entire project thus entailing an expenditure of $10,750,000. The hydro company will pay the government an annual rental for use of the power. It is expected that a yearly average output of 357,000,000 kw-hr. can be produced by the water wheels, operating under a maximum head of 37 ft.

Transmission lines will connect the Ohio Falls development with the Louisville Gas and Electric Co.'s 123,500-hp. Waterside steam plant. By 1929, however, it is expected that the electrical demands of Louisville and surrounding territory will have increased to a point where a large new steam plant will be necessary. Plans have been made for the erection of a steam plant with an ultimate capacity of 250,000 hp., adjacent to the hydro power house.

Beaumont, Texas, to Have 300,000-Kw. Plant

CLOSE TO supplies of natural gas and fuel oil and accessible by road, railroad and steamship, also near the center of the expected load, is the location chosen by the Eastern Texas Electric Co. for its plant known as the Neches Power Station which will have an ultimate capacity of 300,000 kw. and is being designed and built by Stone & Webster, Inc. The site is on the Neches River about 4 mi. below Beaumont, Texas, and has a frontage of about 2400 ft. on the main ship channel.

Concrete on wood piles will be used in the substructure and the superstructure will be of steel frame with permanent walls of brick and temporary walls of corrugated zinc. The turbine room will be 60 ft. wide and long enough to house one generating unit and permit the entrance of a standard gage railroad car across the permanent end. In order to save the expense of long circulating water tunnels, the turbine room will be on the river side of the station, the future electrical bay being on the inshore side with the boiler room between.

Power will be generated by a turbo-generator unit consisting of an 1800 r.p.m. steam turbine direct connected to a 25,000-kv.a., 13,200-v., 3-phase main generator and a 1250 kv.a., 2300-v. auxiliary generator with an auxiliary exciter. The turbine will be of extraction type for regenerative heating of the feed water and will operate with steam at 350-lb. pressure and 700 deg. F. total temperature.

Steam will exhaust into a 35,000-sq. ft. radial flow surface condenser served by two centrifugal circulating pumps with a combined capacity of 44,000 gal. per minute. A temporary control board will be set up in the turbine room as no electrical bay is being installed at present.

Eventually, the boiler room will have a double row of boilers, but in the initial development only one row will be installed. It is planned to install at present two cross

drum Babcock and Wilcox water-tube boilers with 15,300 sq. ft. heating surface to be designed for a safe working pressure of 400 lb. per sq. in. pressure and to deliver steam at 700 deg. F. total temperature. The boilers will be set 22 ft. above the floor and will be fired with fuel oil or natural gas. Provision will also be made in design for the possible installation of pulverized fuel burning equipment.

Two 30,000-bbl. steel tanks, one of which is being installed at present, will constitute the main fuel oil storage plant. The tank will be provided with a steam heating coil as well as a steam smothering line for protection in case of fire.

An outdoor switching station will be designed for an initial installation of one transformer bank stepping up from 13,200 v. to 33,000 v. and 66,000 v. Four 33,000-v. and one 66,000-v. lines will be installed at present, distributing energy to Beaumont, Orange, Liberty and Port Arthur. The transmission line to Orange, which will also be designed by Stone & Webster, Inc., will require an overhead river crossing 800 ft. long and will be 190 ft. above the river at its lowest point. T. R. Thornburg has been assigned the position of superintendent of construction.

Progress Being Made in Deerfield Development

CONTINUED development of the Deerfield Valley project in Vermont and Massachusetts is now under way by the New England Power Co. The latest unit to be developed is known as Plant No. 6, which is located just south of the Vermont-Massachusetts line. The dam will be completed late in 1926. The new dam will be built at the head of No. 5 pond and will set back the water to the tailrace of the Davis bridge project. The new pond will equalize the flow of water from Davis bridge and allow the maximum installed capacity at that plant to be used on a daytime basis without wasting water at No. 5. The plan will necessitate the relocation of about 2 mi. of railroad and a little more than 2 mi. of highway.

Earth will be used in the construction of the dam which will be similar to the Davis bridge and Somerset dams, with a height of 95 ft., giving a net head of 78 ft. maximum width of 500 ft., length of 700 ft., and will contain about 300,000 cu. yd. of material. It will form a pond about 2¼ mi. long with an area of about 250 acres. During construction the river flow will be handled by a conduit 12 ft. in diameter. A straight spillway will be built entirely in ledge on the west bank spilling through a channel excavated in the edge to the river. A private driveway will extend from the highway across a bridge over the spillway and along the crest of the dam to the east side of the river.

The power station will be located at the east side of the river and will contain a single unit of about 10,000-hp., fed by a 15-ft. penstock 300 ft. long. The station will be designed for automatic operation similar to the Searsburg station. Generated at 2300-v., 60 cycles, power will be stepped up to 110,000-v., by means of a bank of 9,000-kv.a., self cooled transformers, located out-of-doors and transmitted over a single circuit H-frame transmission line to the 111,000-v. bus at Davis Bridge. This plant, it is estimated, will have an annual output of 25,000,000-kw-hr.

News Notes

THE CHICAGO-WILCOX MFG. CO., which is an amalgamation of The Chicago Gasket and the Wilcox Mfg. Co., made last February, is now in its new plant at 77th St. and Anthony Ave., Chicago and in full production.

HERBERT B. DWIGHT, engineer with the Canadian Westinghouse Co., has been appointed a professor in the department of electrical engineering at the Massachusetts Institute of Technology at Cambridge, Mass.

THE ELECTRICAL Manufacturers Council, through its Carbon Section, is taking up with the Division of Simplified Practice a proposal that sizes of carbon brushes for motors be simplified. The proposal is meeting with the approval of representative users.

BELOIT WATER, GAS & ELEC. CO., Beloit, Wis., is now constructing an addition to the central generating station to house one additional Stirling 1000-hp. boiler. This addition was designed by Sargent & Lundy, Engineers, Chicago. Construction and installation are being supervised by C. W. Florey, chief engineer of the Beloit plant.

FRANK G. PHILO, who for the past six years has been engaged mainly in preliminary operation of power stations for Stone & Webster, Inc., on September 1, became associated with the Southern California Edison Company as assistant superintendent of steam power generation. Mr. Philo will make his headquarters at the Long Beach Steam Plant No. 2.

THOMAS R. ARCHER, formerly assistant chief boiler inspector of the state of Ohio, has been elected chief boiler inspector of the Delaware Board of Boiler Rules. Rules and regulations issued by the Board are now effective on users, insurance companies and boiler manufacturers and copies of the rules can be obtained by applying to Mr. Archer, Public Bldg., Wilmington, Del.

THE SOUTHERN ILLINOIS GAS CO. has made plans for the extension of the power house at Murphysboro, Illinois. The work will consist of the construction of a new turbine room, the installation of two steam turbo-generators, two motor generator sets for the street car service and two 500-hp. boilers with auxiliaries. The superstructure of the boiler house which was destroyed by the tornado last March will be rebuilt and extensions will be made to the coal handling equipment. New intake and discharge lines will be laid to the Big Muddy River for the circulating water supply. G. I. James of Stone & Webster, Inc., is to be superintendent in charge of construction.

PLANS HAVE been made by the Trumbull Steel Co. of Warren, Ohio, to install a new type of double range Scherbius drive, apparently the first of its kind, in connection with an installation of electrical equipment for driving part of a 16-in. hot strip mill. The complete equipment will include the usual steel mill type of motor and a complete regulating set, all of General Electric manufacture. The motor will be equipped with six collector rings, each end of the three secondary phases being brought to a collector ring. The motor shaft will be extended at each end, at one end for coupling to the gear unit and, at the other, for mounting an ohmic drop exciter rated 14 kv.a., and running at the same speeds as the motor. The regulating set will consist of two machines, each 480 kv.a., 514 r.p.m.; a synchronous motor rated 1175 hp., 514 r.p.m.,

and a d.c. exciter rated 18 kw., 514 rp.m., 125 v., for supplying excitation to the synchronous motor fields. The synchronous motor will replace the usual induction motor, thus providing operation at the maximum possible power factor. The synchronous motor will be started by means of an autotransformer used in conjunction with the switchboard. The two regulating machines allow a higher speed to be used for the set, each unit being one-half the required capacity.

THE BETHLEHEM ELECTRIC CO., Bethlehem, N. H., has awarded contract for a proposed dam and power plant at Bethlehem to the Amburson Construction Co., New York. Howard M. Turner, of Boston, prepared the plans.

THE METROPOLITAN EDISON CO., Reading, Pa., has begun work on the second unit at its Susquehanna plant, Middletown, Pa., which will include the installation of a 30,000-kw. generator and auxiliary equipment, estimated to cost in excess of $1,200,000, with machinery.

CLEARING of the site for the Clark's Rips power project is well under way at Lewiston, Me. More than 2,000,000 ft. of lumber and hundreds of cords of wood are being removed to clear the site for the 50,000 hp. development of the Central Maine Power Co. on the Androscoggin River. The reservoir to be created will extend about 12 mi. upstream and about a mile in width.

THE RED RIVER VALLEY POWER CO., Crookston, Minn., is improving No. 1 Hydro Electric plant at Crookston by the installation of a new Westinghouse generator and a James Leffel & Co. water wheel. The design and construction work is being done under the supervision of C. L. Crossfield, Twin Valley, Minn., assisted by Leonard Peterson, General Manager and Superintendent of the Red River Valley Power Co., Crookston.

CONTRACT HAS been awarded by the Coma Power Co. of New Braunfels, Texas, to the Westinghouse Electric & Manufacturing Co. for the installation of a complete generating unit of 45,000-hp. capacity. Included in the equipment is a 45,000-hp. steam turbine, a 30,000-kw. generator, developing current at 13,800 v., and a 37,500-sq. ft. condenser. The whole layout calls for expenditure of more than a half million dollars.

THE BEMIDJI ELEC. & MFG. CO., Bemidji, Minn., is enlarging the generating capacity of its mill plant. Two Babcock & Wilcox Co. 400-hp. water-tube boilers are being installed, together with accessories, including a Cochrane feed-water heater and a steel stack 6 ft. in diameter by 120 ft. in height. The new generating equipment consists of one Allis-Chalmers 1000-kw. steam turbine. This work is being done under the supervision of R. H. Lewis, of Minneapolis, Minn.

THE ROCHESTER GAS & ELECTRIC CORP., Rochester, N. Y., has contracted with Sulzer Freres, Winterthur, Switzerland, for the installation of a dry coke cooling plant at its local gas-generating station, to cost approximately $250,000. The decision to use the process is the result of a recent visit of J. H. Haftenkamp, general superintendent, to Switzerland, where extensive studies were made of the system, said to be a unique departure in the United States, making possible the conversion of heat, formerly wasted, into steam for heating service. Coke coming from the plant will be placed in two large brick-lined and insulated containers of about 90 T. capacity; by means of fans attached to the containers, inert gases will be drawn into standard boilers, transferring the heat from the coke to the boilers. The constant circulation of the gases takes the heat from the coke, reducing the temperature from about 2000 deg. F., to approximately 500 deg. F. It is said that close to one-third of a pound of steam will be secured from a pound of coke. The construction work will be carried out by the J. G. White Engineering Corporation, New York.

PLANS FOR THE enlargement of the Valmont Station, near Boulder, Colo., have been approved by Henry L. Doherty, of New York City, and other executives of the company. The work will be carried to completion as rapidly as designs are completed and the equipment can be manufactured. Contracts have been let for the expenditure of $600,000 to double the present capacity of the plant. It is expected that the new unit will be in operation within nine months and that the plant will be ready to assist in carrying the irrigation load and the peak demands of the fall and winter of 1926 and 1927. The installation of the new 35,000-hp. generator will bring the capacity of the plant up to 65,000 hp.

Catalog Notes

C. J. TAGLIABUE MFG. CO. has issued a new and revised edition of its catalog of automatic controllers for temperature, pressure, humidity, liquid level, condensation and other factors which are important to the success of industrial processes. In general, the arrangement of the catalog resembles that of preceding editions, but this edition has 16 pages more, a total of 84 pages. In the 6-page introduction, which is entirely new, is stressed the importance of automatic control in various industries for securing uniformity of product and eliminating waste.

There follows an interesting discussion of automatic control problems in a number of industries, and many actual cases are cited, with frequent illustrations.

This book will be sent free of charge upon application to Automatic Controller Division, C. J. Tagliabue Mfg. Co., 18 Thirty-Third St., Brooklyn. N. Y.

THROUGH ITS engineering department, the Lincoln Electric Co. of Cleveland has compiled and just issued an instruction manual on electric arc welders. While attention is given in the 83-page book to the features to be found alone in the Lincoln welders and to the best methods of using the equipment, yet the publication is primarily an instruction book for welding operators. The booklet, illustrated with diagrams and actual photographs showing different sorts of welds and welding jobs, provides nine lessons in welding. The instruction manual has been made comprehensive to meet the normal requirements, both of new and experienced welders.

NEW METHODS for handling coal and ashes in boiler houses are described in a new 68-page book recently issued by Link-Belt Co., Chicago. The book shows installations of the Peck carrier in the boiler houses of many public buildings, such as the new Tribune Tower in Chicago, and in many industrial plants throughout the United States. It also contains much data of interest to engineers and architects and is of particular value to anyone interested in boiler houses and their equipment.

SWITCHBOARDS, their installation, operation and maintenance are fully covered in a new 120-page booklet issued by the General Electric Co., Schenectady, N. Y. This booklet, bearing the number 87,000-E, is illustrated with photographs, diagrams, tables and formulas.